Construction Cost Control in the Eastern Province of Saudi Arabia

by

Samer Ahmad Ibrahim Zamel

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

CONSTRUCTION ENGINEERING AND MANAGEMENT

July, 1991

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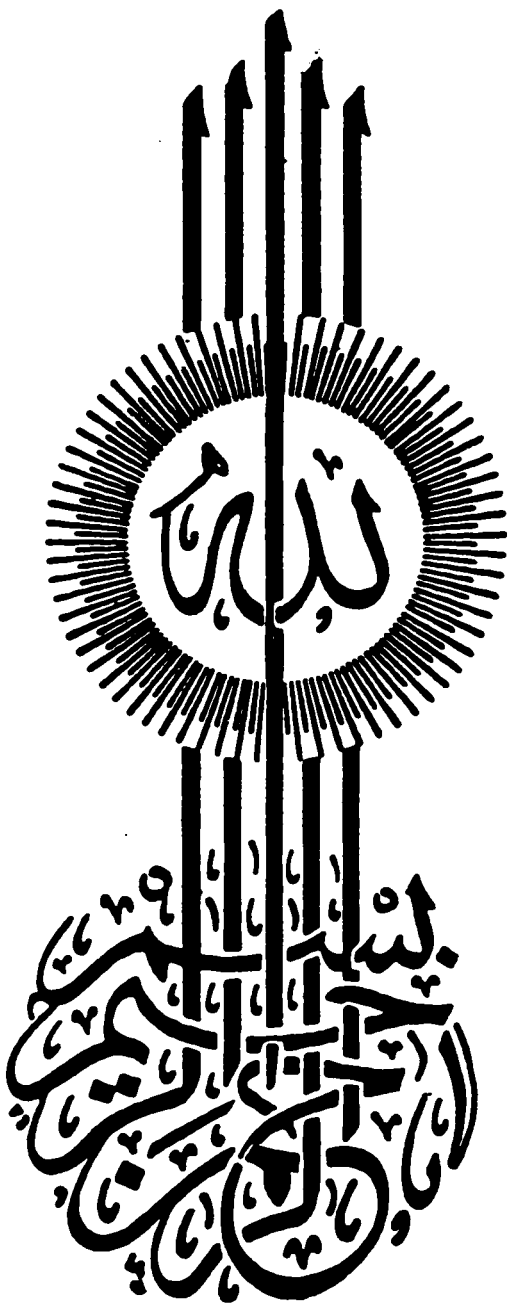
بسم الله الرحمن الرحيم

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This thesis, written by **SAMER AHMAD IBRAHIM ZAMEL** under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the Dean of the College of Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN CONSTRUCTION ENGINEERING AND MANAGEMENT.**

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I DEDICATE THIS THESIS TO THE SUN OF HOPE AND EMBLEM OF SACRIFICE:

MY BELOVED PARENTS

THIS THESIS IS ALSO DEDICATED TO MY SISTER AND MY BROTHER FOR THEIR CONTINUOUS SUPPORT AND ENCOURAGEMENT.

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Finally, I thank all those who helped me in conducting this research.

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THESIS ABSTRACT

FULL NAME OF STUDENT: Samer Ahmad Ibrahim Zamel
TITLE OF STUDY : Construction Cost Control in the Eastern Province of Saudi Arabia
MAJOR FIELD : Construction Engineering and Management
DATE OF DEGREE : July, 1991

This thesis studies the methods followed by the building construction contractors in the Eastern Province of Saudi Arabia to control the project cost as well as the factors that affect the level of control exerted during construction. This study was conducted by series of structured interviews with forty five randomly selected contractors. Results of this study were post-stratified according to the five contractors grades specified by the Agency of Classification of Contractors in Riyadh.

It was found that the contractors in the Eastern Province follow a basic logic sequence in cost control. First, they start by setting the required budget as follows: A) Project estimates are either very general and simple or based on unrealistic assumptions. B) Soil reports form the main source of site analysis. C) Work breakdown structure is based on standard item headings predefined at head office. D) Contractors are unfamiliar with the concept of cost codes. E) A period between 1-4 weeks is most common for short term planning. Second, they measure and report actual costs as follows: A) Charging resources hours is based on personal observations. B) Purchase orders and invoices are mainly used to charge material consumed. C) Systematic procedures for site feedback are lacking. D) Monthly cost statements are the most common tool for cost status reporting. Third, cost variance testing is based on comparing the budgeted vs. the actual cost of work done to date. Finally, the cause(s) of cost variance is investigated by informal methods and incentives form the most popular corrective action. Regarding the factors that affect the level of control, Company Characteristics, Project Characteristics and Project Documents are the most influential. On the other hand, Company Characteristics is the most discriminating factor among the five contractors grades.

MASTER OF SCIENCE
KING KAHD UNIVERSITY OF PETROLEUM AND MINERALS
Dhahran, Saudi Arabia
July, 1991

خلاصة الرسالة

إسم الطالب الكامل : سامر أحمد إبراهيم زامل .

عنوان الرسالة : مراقبة تكلفة التشييد في المنطقة الشرقية من المملكه العربية السعودية .

التخصص : هندسة وإدارة التشييد .

تاريخ الرسالة : محرم ، ١٤١٢ هـ

تناقش هذه الرسالة الأساليب التي يتبعها مقاولو المباني في المنطقة الشرقية من المملكه العربية السعودية لمراقبة تشييد المشاريع .

أيضاً تناقش هذه الرسالة العوامل التي تؤثر على مستوى المراقبة خلال مرحلة التنفيذ . تم التوصل الى نتائج هذا البحث عن طريق مقابلات شخصية مع خمسة وأربعين مقاولاً أختيروا بطريقة عشوائية . تم تحليل وتصنيف نتائج هذه الدراسة طبقا لدرجات المقاولين الخمسة والمحددة من قبل وكالة تصنيف المقاولين في الرياض (وزارة الإسكان والأشغال العامة) .

خلصت هذه الدراسة إلى أن مقاولي المباني في المنطقة الشرقية يتبعون أساليب ذات تدرج منطقي في التطبيق كالتالي : ـ

١ ـ حساب التكلفة التقديرية للتشييد : ـ

أ) حساب التكلفة التقديرية لتشييد المباني إما أن يطبق بصورة مبسطة جدا أو طبقا لإفتراضات غير واقعية .

ب) يعتبر تقرير التربة المصدر الرئيسي لفحص موقع التشييد .

جـ) الأسلوب الذي يتبع في تقسيم هيكل الاعمال يعتمد على مجموعات نموذجية سابق تعريفها في المكتب الرئيسي .

د) عدم الخبرة بالرموز المستخدمة لربط هيكل تقسيم الأعمال والموظفين في المشروع بالمعلومات المالية .

هـ) الفترة الزمنية لتخطيط الأعمال علي المدى القصير تتروح بين أسبوع واحد إلى أربع أسابيع .

٢ ـ حساب ورفع تقارير تكلفة التشييد :

أ) حساب عدد ساعات الأجهزة المستهلكة يعتمد على المراقبة الفردية .

ب) المواد المستهلكة خلال التنفيذ يتم حصرها عن طريق أمر الشراء والفواتير .

جـ) الافتقار إلى أساليب منظمة للحصول على معلومات عن وضع العمل في الموقع .

٣ ـ تقييم الإنحراف في التكلفة الفعلية عن التكلفة المقدرة :

أ) لتقييم وضع المشروع المالي تقارن التكلفة الفعلية للأعمال المنفذة بالتكلفة المقدرة في التخمين لنفس هذه الأعمال .

ب) في حالة الإنحراف عن الميزانية يستخدم التقصي والبحث الغير رسمي لمعرفة السبب .

٤ - معالجة الإنحراف عن التكلفة المقدره : تعتبر الحوافز أكثر الطرق شعبية لمعالجة الإنحراف عن ميزانية المشروع .

٥ - أهم العوامل المؤثرة على درجة المراقبة خلال التشييد هي : خصائص الشركة ، خصائص المشروع ووثائق المشروع .

٦ - أهم العوامل التي تميز بين درجات المقاولين الخمسة من حيث درجة مراقبة التشييد هي خصائص الشركة .

CHAPTER 1

INTRODUCTION

1.1 GENERAL:

One of the main objectives for any contractor entering any construction contract is to realize an acceptable return on his investment. One of the initial steps in the contractual process is preparing a project estimate *. However, a good estimate is not enough to achieve such a desired return. Because of the dynamic nature of the construction industry, and in order for the project to be profitable, a firm *control of resources during construction* should be applied. Realizing this fact, almost all contractors apply - either explicitly or implicitly - some sort of a system to control their project costs.

Nowadays, because of the increasing complexity and the new technological advances achieved in the construction industry, different systems and techniques have been developed and applied. Such systems, either manual or computerized, were developed by the contractors. However, since some of the big companies build their own buildings by themselves, they devote a great deal of time and money to

---

* This estimate may range from a feasibility estimate to a final detailed one.

develop cost control systems specially tailored to their projects.

1.2 THE COST CONTROL SYSTEM:

For any project to be successfully constructed three phases are considered; PLANNING, EXECUTING AND CONTROL. During the control phase three interdependent parameters are usually controlled; cost, schedule and performance. Higher cost usually buys better performance. Cost and time are related in a more complex way, where extra money is paid to compensate for time overrun (1). So the relative importance placed on each of these parameters has a noticeable effect on decisions related to construction cost control, specially when cost overrun is experienced. From the above it can be concluded that cost control forms a subset of the project control system.

Cost control can be defined as the process of achieving a cost objective of the project construction. This cost objective forms the baseline that is compared with the actual cost for timely decisions (the necessary corrective actions)(1,2).

Figure 1 models the operation, flow of information and decision making process of a control system, appropriate for medium to large projects.

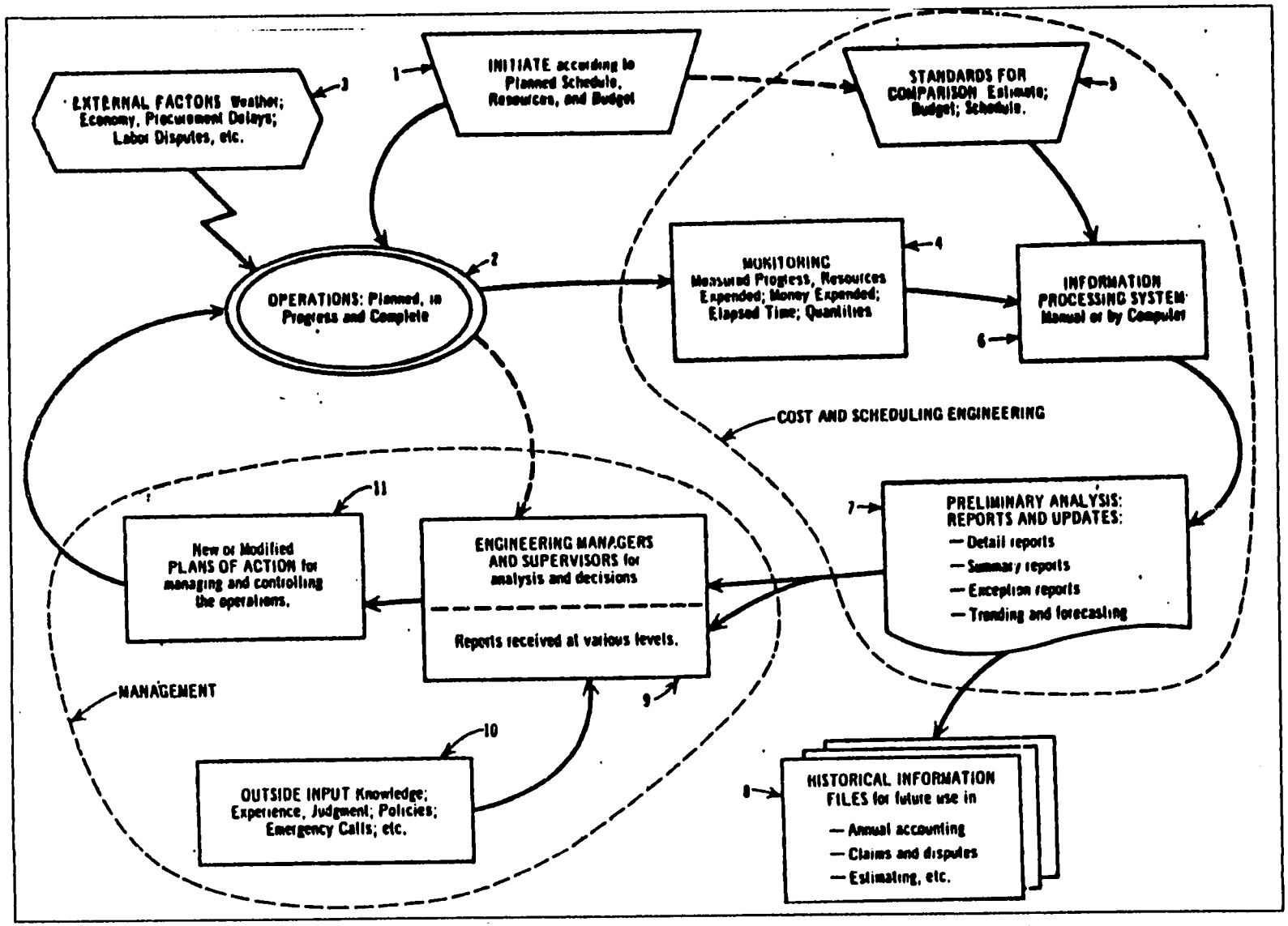

Figure 1: Flow Chart of Project Control System (3).

The basic components of the control system are: (3)

1. Progress measurement (step 4).
2. Creating a standard for comparison (step 5).
3. Data Analysis (step 6).
4. Reporting system (step 7).
5. Corrective actions (steps 9 & 11).

In small projects, it is possible to shorten the path from step 2 to step 9 and provide direct feedback(3).

1.3 PROBLEM STATEMENT:

This research is directed toward answering the following questions:-

1) What methods do Saudi construction contractors utilize to control project cost?

2) Why do they use these specific methods? What are their advantages and disadvantages and how effective are they?

3) What factors influence the level of control in a construction project in Saudi Arabia?

4) What is the ranking (relative importance) of each of the above factors?

1.4 SIGNIFICANCE OF THE STUDY:

As a result of the construction boom experienced in the seventies and early eighties, the construction industry in Saudi Arabia was characterized by great demand placed on contractors services(4). Due to the availability of projects as well as generous governmental grants at that time, cost control was of minor interest to the contractor.

Nowadays, however, the situation is different. Recently, the economical situation has been characterized by limited budgets which have reduced the number of construction projects(4). Because of the great number of contractors and the small number of projects available, competitive bidding has started to play an important role in projects awarding. Consequently, it is expected the contractors have started to pay more attention to construction costs as well as to implement sound cost control systems to achieve their profit targets.

In spite of the important role cost control plays in the Saudi construction industry, no published study explored the methods being utilized by Saudi contractors to control the cost of their construction projects. Due to this lack of knowledge, a need exists to identify these methods.

The degree of cost control may vary from one project to another. Sometimes contractors tend to exert firm cost control in some projects while relaxed control may be exerted in others. Each of the two has a significant effect on the contractor expenditure. Loose control exposes the contractor to the risk of losing his profit or even of realizing a loss. On the other hand, over-control costs the contractor more than it should. If the relative importance of the factors affecting the level of control are known, the job of evaluating cost control methods being practiced becomes easier.

1.5 STUDY OBJECTIVES:

The objectives of the study are as follows:

1. Identify the methods Saudi contractors use to control construction costs.
2. Measure the popularity of use for each method. This will be measured by the percentage of contractors who use each method.
3. Study the reasons for, and the advantages, disadvantages and effectiveness of using each method.
4. Identify the factors that affect the level of control in construction projects and their relative importance.

1.6 SCOPE AND LIMITATIONS:

The above mentioned objectives were directed toward cost control during the *Construction Phase* of projects. Different *project sizes* were included in this study. These sizes are based on the standards specified by the Agency of Classification of Contractors as will be seen in chapter 3. Since building construction constitutes the bulk of the Saudi construction industry, this research will be limited to the *building contractors*. Due to the lack of resources (time and money), this research is limited to the *Eastern Province* of Saudi Arabia.

CHAPTER 2

LITERATURE REVIEW

A general review to the literature will lead to the conclusion that construction cost control has been widely researched. However, very little has been written about cost control in Saudi Arabia in particular.

The literature review of this chapter consists of the following:

1) General discussion of the basic concepts of cost control systems and their criteria.
2) Survey of some of the available cost control systems. However, it is noticed that all of the available cost control systems were developed outside Saudi Arabia.
3) Evaluation to the above cost control systems according to the criteria illustrated in part # 1 of the Literature Review.

2.1 BASIC CONCEPTS OF COST CONTROL SYSTEMS:

For any cost control system to be effectively implemented, it should include the following:

1) Cost baseline (yardstick).
2) Measuring and reporting actual construction costs.
3) Comparison between the cost baseline and the actual costs.
4) Determining causes of high costs and taking the necessary corrective actions.

2.1.1 COST CONTROL BASELINE:

Mostly, cost baseline is mainly the estimator price. However, total dependence on the estimator price may not be enough. Usually, the estimator price should be adjusted in accordance with thorough site analysis as well as historical records of previous projects performance figures. These standard performance figures are multiplied by management condition factors and job condition factors to suit the project in hand (5).

2.1.2 MEASURING AND REPORTING ACTUAL COSTS:

2.1.2.1 ACTUAL COMMITMENTS AND EXPENDITURES:

One of the most important registers to be maintained is the *Commitment Register*. For equipment and material, the sources of actual commitments are: Requisitions, Purchase Orders and Letters of Intent. One of the preferable methods in this respect is to report gross commitments and this entails adding to the face value of a document any packing and shipping charges, provision for escalation - if appropriate - as well as an allowance for possible design changes (6).

Subcontract commitment value is obtained from an agreed contract or letter of intent (6).

In-house commitments are usually recorded as expenditure occurs. Man-hour costs are normally obtained from the corporate man-hour reporting system that originates from the time-sheets data. Other in-house costs, such as personnel expenses, printing, telephones ... etc, can be obtained from in-house receipts completed by the actual users (6).

Actual expenditures occur in most instances long after commitment and are therefore of less value in project cost control. Actual expenditures should, in a well-run company, be provided from the official accountancy records. The

accountants who deal with these charges are normally corporate personnel and have therefore no real knowledge of any one project. Consequently, expenses are subject to incorrect coding and it requires a project-oriented cost-man to spot inconsistencies and arrange for corrections to be made (6).

To improve the speed of reporting expenditure, it is usually inclusive of accruals. In other words, it should include: (6)

- Invoices paid
- Invoices received but not yet paid.
- Work done by contractors but has not yet been invoiced.
- Goods received but not yet invoiced.

To calculate the commitment, two main approaches are illustrated in the literature: (7)

1) *The Use of Actual Paid Rates*

This is derived from project documents, such as labor wage sheets. This technique of costing has several disadvantages, such as:

a) Discrepancies (losses or gains) may not be due to productivity causes; e.g. fringe benefits to construction workers are not generally under the control of site manager.

b) The dependance of the cost control system on the preparation of total wage and add-on costs by the accountants.

c) If daily allocation sheets are not used, there may be a difficulty in apportioning the weekly labor costs from the wage sheets to different items of work.

d) There may be a need for excessive adjustments for labor add-on costs.* (7)

2) *The All-in Rates Approach*:

All-in Rates refers to the estimated total cost per hour of various crafts and/or plant as derived by the estimator at the time of tendering for the purpose of pricing the job. Such rates are kept constant for converting hours to dollars. The advantages of using this approach are: (7)

a) Cost statements may be prepared as soon as work on the last day of the week is completed.

b) The discrepancies are only due to productivity losses, which are usually controlled by the site manager.

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* Add-on costs are those expenses which - in addition to the wages paid to employees - will fall upon the employer as a corollary to payment made for hours worked, such as housing & transportation allowances.

c) Less data manipulation is involved in preparing the cost statements.

d) Losses due to escalation of labor, plant and material costs do not show as a discrepancy since these are beyond the control of the site manager.(7)

The disadvantages and their remedies in using All-in Rates are as follows:

a) It is difficult to reconcile the actual costs estimated using all-in rates with figures obtained from the payroll summary. However, this may be remedied by reconciling hours rather than dollars.

b) Some add-on costs which are in the control of site managers cannot be controlled using all-in rates. However, such add-on costs may be monitored separately.(7)

2.1.2.2 REPORTING SYSTEM:

The project reporting system is considered one of the most important tools for timely evaluation against any cost hazards.

Reports can be classified according to their frequency as follows:-

1) Regular-interval reports.

2) Increased frequency, where, as the project progresses, the frequency of reporting increases.
3) Decreased frequency, where, as the project progresses, the frequency of reporting decreases.
4) Random-interval reports (based on project milestones).

Reporting period is affected by: (5)

1) Desired level of control.
2) Reporting period should justify its expenses (cost of reporting).
3) Confidence in estimate.
4) Project characteristics.
5) Owner requirements.
6) Occurrence of unexpected events.

The contractor progress reports may consist of the following: (5)

1. **Daily Reports:**

Normally, a daily report covers only one operation or one phase of work. This type of report generally covers only labor, equipment operations and work done (quantities) on daily basis. A superintendent using daily reports soon establishes a gage for progress and can readily diagnose job weaknesses or

trouble spots.

Examples of daily reports are:-

a. Daily labor cost memo: (Fig. 2)

b. Daily force report: (Fig. 3)

2. Weekly Reports:

Generally a weekly report covers all of the items of work or the major items as a minimum (5).

3. Monthly Reports:

It is the general practice for the job accounting department to prepare a monthly cost statement. The format of the statement varies from one contractor to another, but generally the following information is included: (5)

a. Bid estimate quantities, costs and unit prices.

b. Cost to date broken down into labor, equipment, materials, subcontract and total cost.

c. Quantities and unit costs to date .

d. Overrun or underrun in cost to date.

This information is prepared for both the direct and indirect items of costs.

4. Other Reports: This may include, forecast of final cost, schedules, man-hour reports, final cost report and project history (5).

DATE Apr. 11, 1984

MR. Superintendent

DAILY LABOR COST MEMO

JOB COSTS FOR LABOR ONLY ARE AS FOLLOWS:

ITEM OF WORK	DATE: 4/10 QUANTITY	UNIT	DATE: 4/9 QUANTITY	UNIT
Earth excavation	4627	.30	5720	28
Rock	1051	3.11	1690	3.04
Concrete paving	460			
Form Size 5½" x 8½"				

REMARKS Earth loaded by shovel, hauled by Euclids.

COST ENGINEER

Figure 2 : Daily Labor Cost Memo(5).

CONSTRUCTION COMPANY

DATE _____ 1st Shift

FORCE REPORT

Contract For:

DATE _____ 2nd Shift

	PREVIOUS # OF MEN	TERMINATIONS YESTERDAY	HIRES TODAY	TOTAL ON P/R	ABSENT TODAY	WORKING TODAY
Administration						
Supervision						
Engineering						
Q.A. Department						
Business						
Warehouse						
Safety						
Nurse						
TOTAL SALARY						
Boilermakers						
Tech. Engs.						
Laborers						
Oper. Engs.						
Carpenters						
Millwrights						
Teamsters						
Cement Mas.						
Bricklayers						
Ironworkers						
TOTAL HOURLY						

SUBCONTRACTORS	Administration	Business	Supervision	Detailers	Q.A.	Tech. Eng.	Operating Eng.	Carpenters	Teamsters	Ironworkers	Cement Mas.	Asbestos	Sheet Metal	TOTALS

Figure 3 : Daily Force Report(5).

2.1.3 ACTUAL VS. BASELINE COSTS:

Variance from budgeted costs may be the result of one or more of the following: (8)

a) Construction performance.

b) Poor technical and administrative performance, such as in design of the facility or in the purchase of materials.

c) Error in the preparation of estimates, although it is assumed here that the estimate is reasonably accurate.

d) Special circumstances which have an effect on the site in particular, such as strikes and poor weather.

Performance and degree of variation is usually measured by comparing the cost of work done to date with the budget of equivalent amount of work, as well as comparing the planned with actual completion time (9). Different methods and techniques have been developed to measure performance. The most widely used techniques are as follows:

a. Cost Variance:

Cost Variance (CV) is defined as the difference between the budgeted (BCWP) and the actual cost of work performed (ACWP) at any point over the life of the project: (10)

$$CV = BCWP - ACWP \quad \{1\}$$

b. Accounting Variance:

Accounting variance, or spending variance, is the difference between the budgeted cost of work scheduled (BCWS) and actual cost of work performed (ACWP): (10)

$$AV = BCWS - ACWP \quad \{2\}$$

c. Schedule Variance:

Schedule variance is defined as the difference between the budgeted cost of work performed (BCWP) and budgeted cost of work scheduled (BCWS): (10)

$$SV = BCWP - BCWS \quad \{3\}$$

Schedule variance provides valuable information on the progress of the project in terms of schedule. However, S.V. cannot positively indicate whether or not any specific task or milestone has been accomplished. This is because the actual sequence and timing of various activities may be different from those planned.

d. At Completion Variance:

At completion variance (ACV) is defined as the difference between the budgeted cost at completion (BAC) and the estimated cost at completion (EAC): (10)

$$ACV = BAC - EAC \quad \{4\}$$

Specific interpretations of various possible values of these variances are summarized in Table 1 (10).

VARIANCE	NEGATIVE	ZERO	POSITIVE
Cost Variance (CV)	Over cost	On cost	Under cost
Accounting Variance (AV)	Over budget	On budget	Under budget
Schedule Variance (SV)	Behind schedule	On schedule	Ahead of schedule
At Completion Variance (ACV)	Forecast over budget	Forecast on budget	Forecast under budget

Table 1 : Interpretation of Variances (10).

e. Performance Ratios:

Performance ratios provide additional insight into the status of the project in relative terms. Three such performance ratios are illustrated here: (10)

1) Cost-Performance Ratio:

Cost performance ratio (CPR) measures the cost efficiency of the work accomplished. CPR is defined as the ratio of the cumulative budgeted cost of work performed (BCWP) over the cumulative actual cost of work performed (ACWP): (10)

$$CPR = \frac{BCWP}{ACWP} \qquad \{5\}$$

As an example, a CPR of 0.90 indicates that 90 contract-dol-

lars worth of planned work has been completed for every 100 actual dollars spent.

2) Schedule-Performance Ratio:

Schedule-performance ratio (SPR) indicates the schedule efficiency of the work completed to date. SPR is the ratio of the cumulative budgeted cost of work performed (BCWP) over the cumulative budgeted cost of work scheduled (BCWS): (10)

$$SPR = \frac{BCWP}{BCWS} \qquad \{6\}$$

For example, a SPR of 0.80 indicates that only 80 contract dollars worth of work has been accomplished to date for each 100 contract- dollars worth of work scheduled.

3) Completed Work Ratio:

Completed Work Ratio (CWR) is a "percent complete" measure. CWR is defined as the ratio of the cumulative budgeted cost of work performed (BCWP), over the budgeted cost at completion (BAC): (10)

$$CWR = \frac{BCWP}{BAC} \qquad \{7\}$$

As an example, a CWR of 0.25 indicates that if the total budgeted cost at completion were $100, a total of 25 contract dollars worth of work would have been accomplished to

date. That is the project is 25% complete as of the report date. Some authors add a Management Reserve (MR) to the denominator as an allowance contingency: (10)

$$CWR = \frac{BCWP}{[BAC + MR]} \qquad \{8\}$$

All of the above three ratios are interpreted in such a way that a ratio of 1.00 indicates that the project progress is on target. A ratio of larger than 1.00 indicates that the progress has surpassed plans and expectations whereas a ratio of less than 1.00 points out an unfavorable progress. Specific interpretations of these ratios are illustrated in Table 2 : (10)

Performance Ratio	Less than one	Equal to one	More than one
Cost Performance Ratio (CPR)	Over cost	On cost	Under cost
Schedule Performance Ratio (SPR)	Behind schedule	On schedule	Ahead of schedule
Completed Work Ratio (CWR)	% complete = 100% CWR	Project complete	Incorrect CWR

Table 2 : Interpretation of Performance Ratios (10).

f. Integrated Cost/Schedule Performance Curves (Achieved Value Method):

This curve is mainly a visual tool to cost control by summing costs, performance and time. This device, which provides meaningful feedback during the project, makes it easier to prepare forecasts regarding where the project is headed, so corrective actions can be applied when necessary (Figs. 4,5)(11,12).

The degree of sophistication of an integrated cost/schedule varies with the size and scope of a specific project. Both single and multiple curves can be developed depending on the complexity of the project and the needs of the manager (11,12).

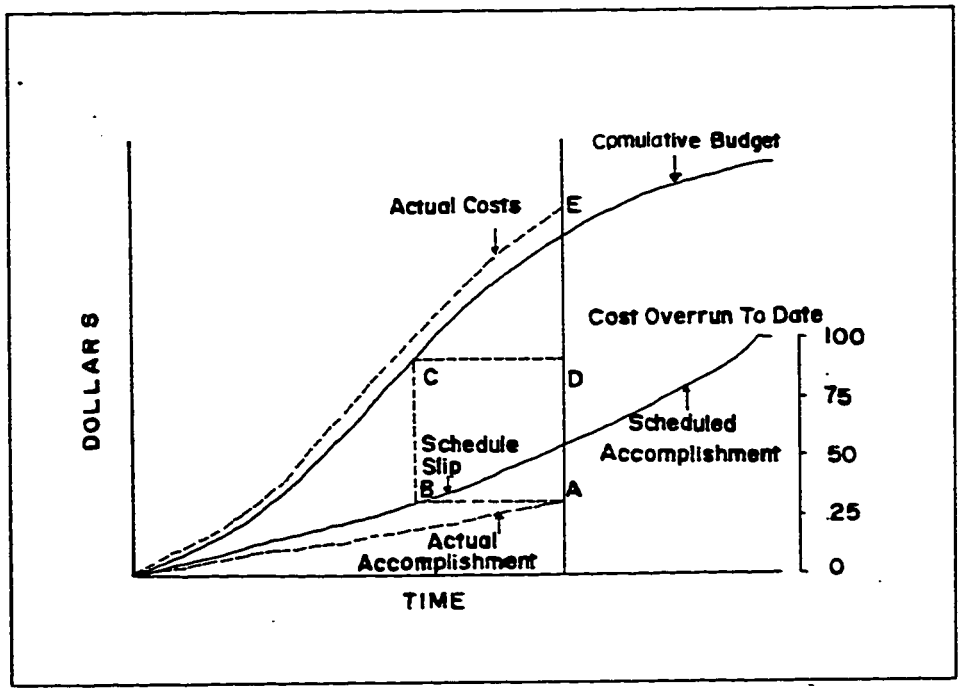


Figure 4 : Integrated Cost/Schedule Report (11).

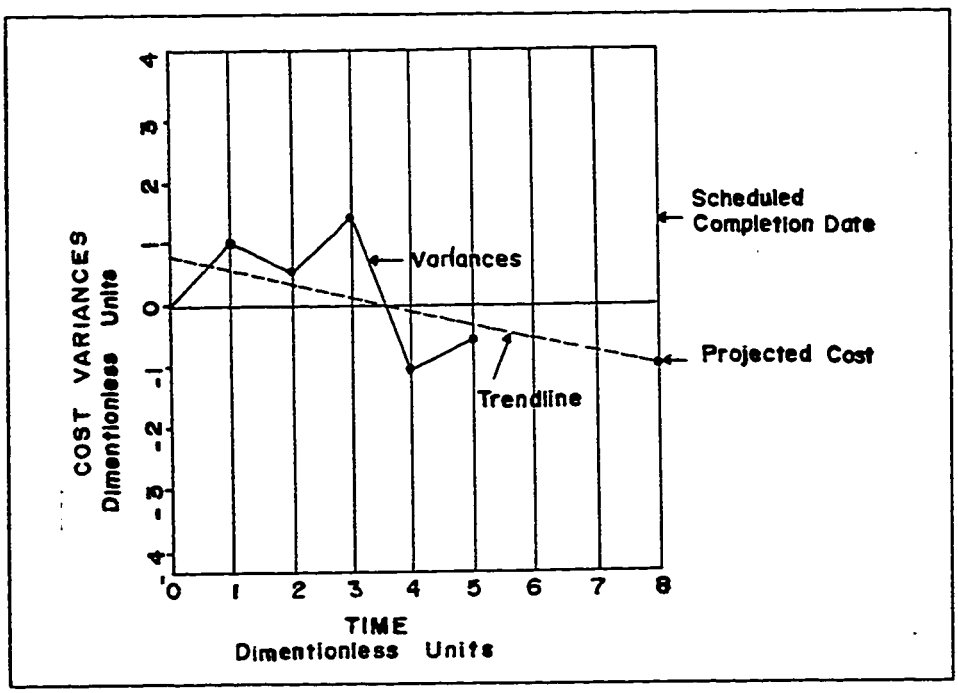


Figure 5 : Integrated Cost/Schedule System (11).

2.1.4 CAUSES OF HIGH COSTS AND CORRECTIVE ACTIONS:

In the case of any cost deviation, the first reaction is to determine the cause. Once the cause(s) of this discrepancy is determined, corrective action(s) can be applied.

Due to their highly related nature, determining causes of deviation as well as corrective actions are usually discussed together. Various approaches for determining causes of deviation as well as correction actions are addressed in the literature and among these are: periodical supervisory intercommunication, spot costing*, work study and incentive schemes (5,7,13,14,15).

The end reaction of a corrective action may include:

- Adding resources.
- Transferring resources from non-critical activity, to critical activities by using the float available in the critical path activities.
- Elimination or transferring activities to other projects.
- Change in logic of network activities.
- Substitution of resources and methods.

---

* Spot costing is disclosing the specific problem in an item by costing the component operations within that item on a very detailed basis.

Sometimes *doing nothing*, except to update the reporting system to reflect the reality of the job, is the best action. The point here is that one should not take corrective actions merely for the sake of making the job confirm to original plans. Due to the dynamic nature of the operations of the projects, the situation as it exists might actually be better in some ways than what was planned (3).

2.1.5 CHARACTERISTICS OF AN EFFECTIVE COST CONTROL SYSTEM:

In spite of the subjectivity in selecting or developing a cost control system, an effective cost control system should possess the following characteristics: (16)

1. Provide good control during construction, by spotting cost trouble areas, aid to take corrective actions, and measure the effectiveness of the action taken.

2. Simple where it is understood by low level people.

3. Flexible in usage, where it allows ease of updating and fitting to the organization structure of the company concerned.

4. Control schedule, where any slippage in project execution schedule would cost the contractor more, due to resource consumption and paid liquidated damages.

5. Control performance: the control system should control the cost of construction while maintaining the specified level of performance for the project.

6. Feedback provision: where data about project status as well as the resources involved are continuously reported.

7. Provide Data for evaluation of variation by comparing actual work to the estimated.

For more information regarding the cost control systems and their components, refer to references 17 to 32.

2.2 COST CONTROL SYSTEMS SURVEY:

This part of the research presents some of the available cost control systems addressed in the literature.

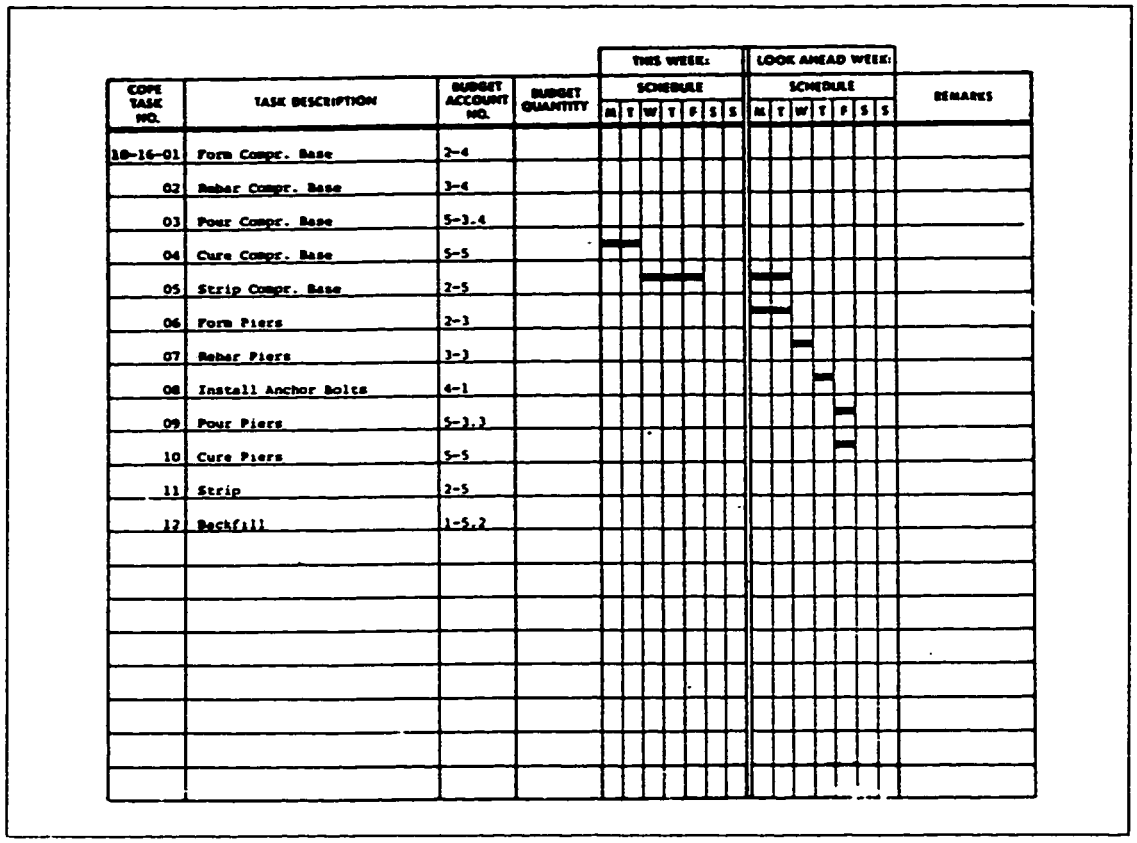
2.2.1 COPE: A CONSTRUCTION MANAGEMENT TECHNIQUE

This technique was developed to allow more effective implementation of C.P.M. networks. This approach depends an integrating the C.P.M. network activities with their detailed tasks (33).

The implementation of COPE method begins by breaking C.P.M. activities into their mini-networks, or COPE TASKS, which are presented in a sheet called COPE TASK SHEET (Fig. 6) (33). This sheet is prepared weekly, so the number of cope task sheets equal the number of weeks in the expected duration of the present C.P.M. activity (33).

This sheet, which forms the basis for drawing project BAR CHART, provides two spaces, one for the current scheduled week and the other for the following week (33).

By using task numbers and budget account numbers, this sheet forms the basis for preparing FOREMAN'S DAILY REPORT and CRAFT TASK AND MAN-POWER SUMMARY REPORTS (Figs. 7,8) (33).



COPE TASK NO.	TASK DESCRIPTION	BUDGET ACCOUNT NO.	BUDGET QUANTITY	THIS WEEK: SCHEDULE M T W T F S S	LOOK AHEAD WEEK: SCHEDULE M T W T F S S	REMARKS
10-16-01	Form Compr. Base	2-4				
02	Rebar Compr. Base	3-4				
03	Pour Compr. Base	5-3.4				
04	Cure Compr. Base	5-5				
05	Strip Compr. Base	2-5				
06	Form Piers	2-3				
07	Rebar Piers	3-3				
08	Install Anchor Bolts	4-1				
09	Pour Piers	5-3.3				
10	Cure Piers	5-5				
11	Strip	2-5				
12	Backfill	1-5.2				

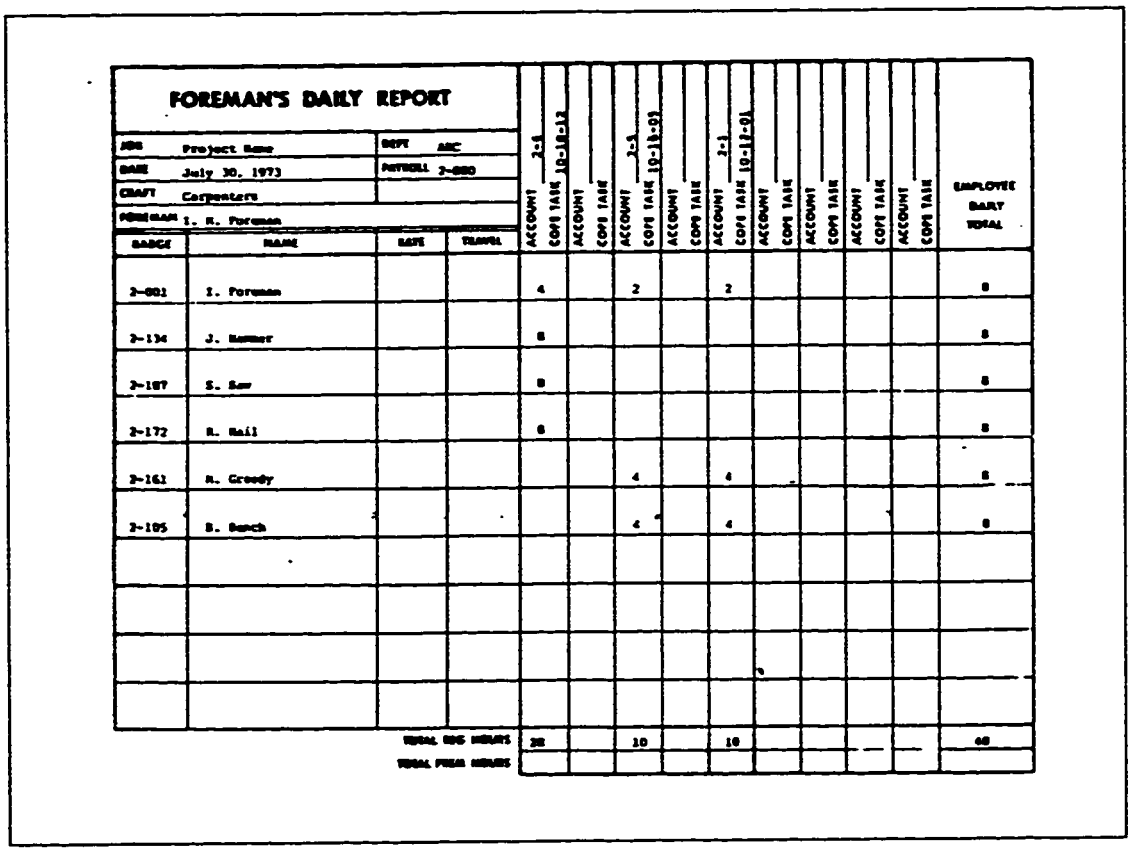
Figure 6 : Cope Task Sheet (33).

CRAFT CARPENTERS

WEEK OF JULY 30, 1973

COPE TASK NO.	TASK DESCRIPTION	SCHEDULE M 30	T 31	W 1	T 2	F 3	S 4	S 5	M 6	T 7	W 8	T 9	F 10	S 11	S 12	FOREMAN
10-08-12	Form pipe suppt. piers 201-210	4	4	4	4											I. M. Foreman
15	Strip pipe suppt. piers 101-106								2	2						"
16	Strip pipe suppt. piers 201-210										2	2	2			"
10-16-05	Strip Compressor Base	2	2													"
06	Form Compr. Piers			4	4	4			4	4						"
11	Strip												2			"
10-22-05	Form East Wall	4	4													
06	Form South Wall			4	4											
07	Form West Wall					4			4							
08	Form North Wall									4	4					
10-20-03	Form N. E. Quad Fl. Slab Cooling Twr.			2	2											
04	Form N. W. Quad Fl. Slab Cooling Twr.				2	2										
05	Form S. E. Quad Fl. Slab Cooling Twr.								2	2						
06	Form S. W. Quad Fl. Slab Cooling Twr.										2	2				
15	Place PVC Water STOP			1	1	1			1	1	1	1				
10-12-01	Form Exchanger Base	4														I. M. Foreman
04	Form Exchanger Pedestals			4	4	4										"
07	Strip Exchanger Foundation												4			"
10-14-01	Form Pump Base	2														
04	Form Pump Pedestal			2	2											
07	Strip Pump Foundation								4							
	DAILY TOTAL	16	10	21	23	15			17	13	9	5	8			

Figure 7 : Craft and Manpower Summary (33).



FOREMAN'S DAILY REPORT

JOB Project Name	DEPT ABC
DATE July 30, 1973	PAYROLL 2-000
CRAFT Carpenters	
FOREMAN I. M. Foreman	

BADGE	NAME	DAYS	TRAVEL	ACCOUNT 2-1 / COST TASK 10-12-12	ACCOUNT / COST TASK	ACCOUNT 2-1 / COST TASK 10-12-01	ACCOUNT / COST TASK	ACCOUNT 2-1 / COST TASK 10-12-01	ACCOUNT / COST TASK	ACCOUNT / COST TASK	ACCOUNT / COST TASK	ACCOUNT / COST TASK	ACCOUNT / COST TASK	EMPLOYEE DAILY TOTAL
2-001	I. Foreman			4		2		2						8
2-134	J. Hammer			8										8
2-187	S. Saw			8										8
2-172	H. Nail			8										8
2-161	H. Greedy					4		4						8
2-105	B. Bench					4		4						8
	TOTAL ABC HOURS			28		10		10						40
	TOTAL PAYA HOURS													

Figure 8 : Foreman's Daily Report (33).

2.2.2 AN OWNER'S APPROACH TO PROJECT CONTROL

This approach was developed by a major industrial company called ALCAN AUSTRALIAN LTD. to build an expansion of its aluminum smelter, which had an estimated cost of $200 million (34).

The project control organization included estimating, cost engineering and planning and scheduling. Each section was organized into specific areas of responsibility. This system depended on multi-level work breakdown structure as a basis for data identification throughout the project control and accounting system (34).

The company's philosophy required cost forecasts to be prepared at quarterly intervals. Such forecasts were a complete re-estimate of the scope of the project. In addition to the above quarterly reports, a monthly forecast of cash disbursements was issued and continuously updated. As part of the quarterly forecasts, the project progress curve was also revised to reflect the forecasted project work hours and actual schedule data experienced during the quarterly period (34).

This project control system was based on the accrual basis where the value of work in place were measured to reflect current period activity. The basis upon which this

basis functioned was the progress payment certificate (Fig. 9) (34).

These progress and accrual results were entered into the computer system for processing and production of necessary reports which formed the basis for cost control or accounting purposes (34).

Performance during construction was measured by means of performance and percent to complete ratios.

CONTRACTOR:
CONTRACT TITLE:
CONTRACTOR No.:
PROGRESS PAYMENT No.:
PERIOD: TO

COST ACCOUNT	ITEM No.	DESCRIPTION	COMMITTED				PERIOD		CUMULATIVE	
			UNIT	QTY.	UNIT RATE	AMOUNT	QUANTITY OR % COMPLETE	AMOUNT	QUANTITY OR % COMPLETE	AMOUNT
900-E10290	1.1	Establishment	-	-	L.S.	28,000.00			80	22400
760-010000	1.2	Site Preparation	-	-	L.S.	26,020.00			100	26020
760-071200	1.3	Drains and Roadwork	-	-	L.S.	19,986.00	10	1999	100	19986
760-141000	1.4	Reinforced Concrete Slab including Formwork and Rebar	-	-	L.S.	94,542.00			100	94542
760-221000	1.5	Structural Steel - Supply, Fabricate and Erect	-	-	L.S.	71,669.00			100	71669
760-320100	1.6	Brickwork - Supply and Erect	-	-	L.S.	34,763.00			100	34763
760-320200M	1.7	Internal Partitions, Ceilings, Doors, Windows - Supply	-	-	L.S.	115,881.00	5	5794	90	104293
760-320200	1.8	Internal Partitions, Ceilings, Doors, Windows - Install	-	-	L.S.	38,045.00	5	1902	90	34240
760-320310M	1.9	Air Conditioning and Ventilation - Supply	-	-	L.S.	220,285.00	10	2208.75	95	209271
760-320210	1.10	Air Conditioning and Ventilation - Install	-	-	L.S.	90,365.00	20	18073	90	81328
760-320300	1.11	Internal Finishes including Painting and Tiling - Supply and Install	-	-	L.S.	51,480.00	5	2574	70	36036

CONTRACT COMPENSATION (INCLUDING C/O NO: 1 TO 7 1 : $ 1,737,324.00

SUBMITTED BY CONTRACTOR: _____ DATE: _____

QUANTITIES CHECKED BY CONTRACT SUPERVISOR: _____ DATE: _____

AUTHORISED BY AREA MANAGER: _____ DATE: _____

AUTHORISED BY CONTRACTS ADMINISTRATION MANAGER: _____ DATE: _____

APPROVED BY CONSTRUCTION MANAGER: _____ DATE: _____

APPROVED BY COMMERCIAL MANAGER: _____ DATE: _____

TOTALS:	188745.30	1,552,668.80
RETAINED:	18874.61	155,266.88
DIFFERENCE:	169870.69	1,397,401.92
LESS ADJ TO AMT RETAINED:	0.06	
P.P.S:	169870.69	
LESS PREVIOUS PAYMENTS:		-1,227,531.73
NET AMOUNT THIS PAYMENT:		169,870.69

Figure 9 : Progress Payment Certificate (34).

2.2.3 SACCS: SCHEDULE AND COST CONTROL SYSTEM.

This system is mainly a computerized one developed by Foster Wheeler. This system is characterized by strong emphasis on construction labor cost item, which is combined with both schedule and volume of work scope (35).

By this technique, many job evaluation computation formulae were programmed into the computer so schedule, productivity and rate of production are monitored (35).

SACCS is sensitive to the level of reporting, so roll-up summary reports for management, formatted work scope or like items of work reports for job supervision, and level of input reports that report on the data feed to the system, could be obtained (35).

Various types of management level reporting can be obtained. This include weekly reports, construction management reports, project summary report, and man loading report (Figs. 10,11)(35).

Another type of reports that could be obtained is JOB CONTROL OUTPUT REPORTS. These include construction activity reports and labour productivity reports (35).

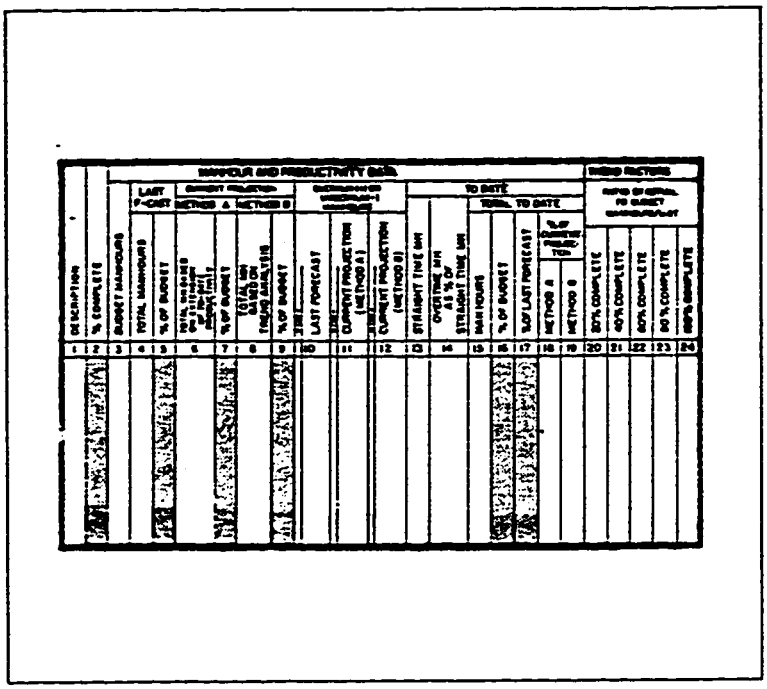


Figure 10 : Construction Management Reports (35).

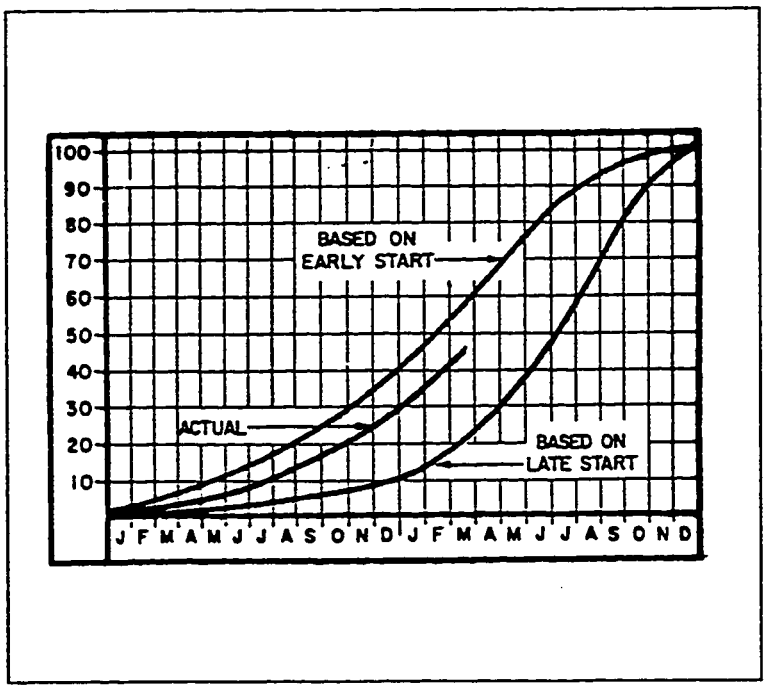


Figure 11 : Project Summary Reports (35).

2.3 SYSTEMS EVALUATION

By the previously mentioned techniques, we can see the variation in the approaches followed to control projects. In order to get more insight into the difference between the three approaches, an evaluation of each will be conducted.

In the first system, which integrates C.P.M. scheduling with short term planning can be criticized for several shortcomings:

1. No clear presentation and analysis to the cost item of the project where all that it shows is a budget account number on the cope task sheet. This oversimplified presentation of the project monetary items prevents analyzing the effect of project progress on the project cost at different construction phases and at the end of the project.
2. This system works mainly as a scheduling technique where it lacks a feedback system to the job progress by means of periodic reporting about project status.
3. Using this system, it is difficult to detect problem areas for timely corrective actions.
4. This system is generally formulated in such a way that it cannot be applied to any project in particular without being supplemented with the necessary reporting and other control techniques that depend on the

nature of the project.

In the second approach, which was developed by the owner himself, we can see how detailed he was in applying his techniques. This is mainly due to the full knowledge about the project and its needs. In spite of the fact that this technique proved to be effective when it was applied, it is doubted that it can be applied to another project without modification. This is due to the fact that this system was developed for a particular project with special requirements and nature.

The third system is mainly an articificial intelligence. This system is mainly programmed with the necessary techniques to control projects construction. This makes it implementable and flexible enough to be adapted to different projects according to their nature. However, what is important to notice is the following:

1. SACCS is not a system by itself, but it is mainly a tool that could be adapted by project personnel to provide them with the necessary information and actions to control their projects.
2. This system depends mainly on integrating man-hours with other resources. However, many projects, such as the industrial ones, are not labor intensive and labor cost is of no significant value.

3. Using a programmed computer system to be utilized throughout the project, and specially in decision-making for corrective actions, limits the creativity of project personnel and the process becomes a repetitive one with little human participation.

Table 3: Summary Evaluation for the Three Systems Based on the Criteria Listed in Page 26.

Parameters	1	2	3	4	5	6	7
Systems # 1	X	X	X	✓	✓	✓	✓
Systems # 2	✓	✓	✓	✓	✓	X	✓
Systems # 3	✓	✓	✓	✓	✓	X	✓

Parameters Codes:

1. Immediate attention to any problem
2. Feedback provision
3. Provide data for valuation of variation
4. Control Performance
5. Control schedule
6. Simple
7. Flexible

From the results shown in the table, the second and third systems proved to be superior compared to the first one. However, despite the close results the two systems have in the evaluation, the second system is considered the best. This is due to the fact that for any project cost control

system to be effectively implemented, it should originate from the special needs of the project involved.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter presents all the issues related to the methodology followed in chapter four to achieve the research objectives.

3.1 DATA REQUIRED

The objectives of this study necessitated the collection of information regarding the methods of cost control and the factors affecting the level of control.

A. Methods of construction cost control:

These are the tools used by the contractors to control cost during construction*.

These tools include:

1- Construction budgeting.

2- Resource costing during construction.

3- Reporting construction cost.

4- Cost variance and corrective actions.

The popularity of use for each method was measured by the

---

* Since, to the best knowledge of the researcher, no standard system or methods of cost control is(are) followed by Saudi contractors, this research investigates the tools used to control construction cost.

percentage of contractors using each method.

The advantages and disadvantages of, and the reasons for, using each tool were collected. In addition, the degree of effectiveness of each tool was measured using a Likert scale ranging from 1 to 7.

B. Factors affecting the level of control:

An extensive review of the literature revealed six major potential factors that may affect the degree of control applied over a certain project or a phase of the project (36,37) These factors are; project characteristics, project documents, labor, equipment, company characteristics and outside influences. These factors were further subdivided into thirty-one potential factors (Appendix A, Part III)(36,37).

The level of control was operationalized by three parameters; Frequency of Reporting (Freq. of Rep.), Degree of Work Breakdown Structure (W.B.S.) and Degree of Organization Breakdown Structure (O.B.S.)(Fig. 12).

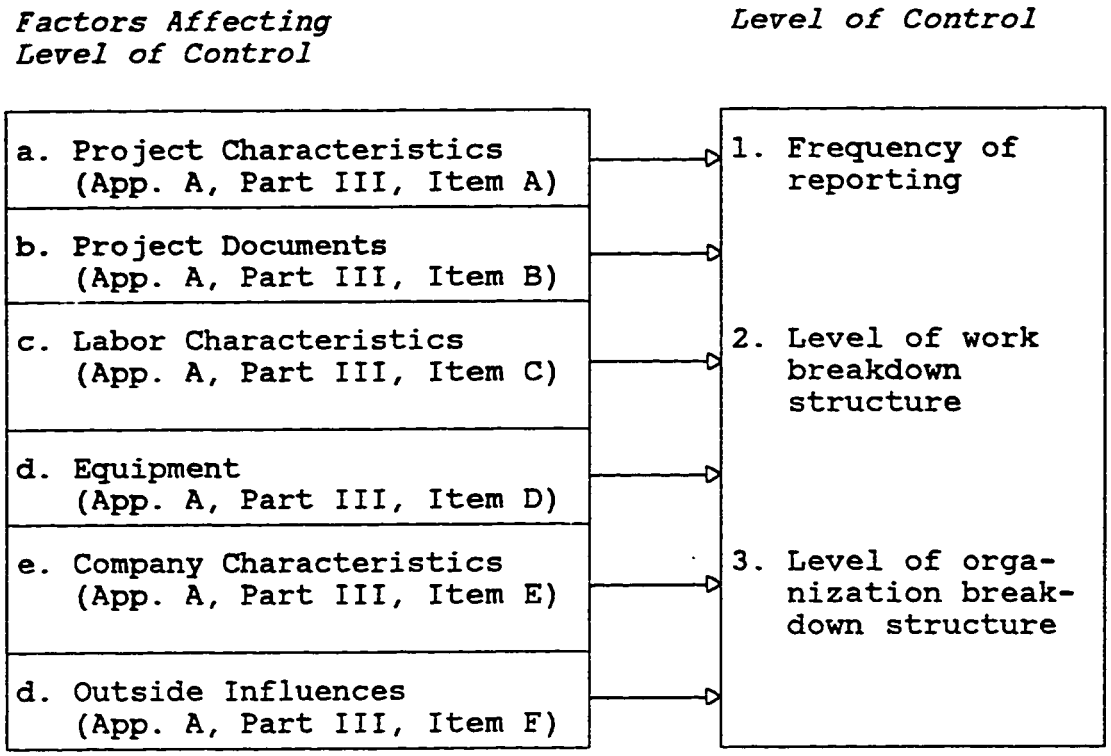


Figure 12 : Level of Control and Influencing Factors.

3.2 DATA COLLECTION

Data required for this research was obtained through structured interviews with a sample of the contractors in the Eastern Province of Saudi Arabia. These interviews were held while filling a previously prepared questionnaire (interview schedule) as will be explained later in this section.

The results of a similar study conducted in Australia formed a major source in increasing the researcher's awareness regarding the different tools of construction cost control practice upon which the questionnaire is based (7,14).

The questionnaire is divided into three sections. The first section is related to the respondents' organizations, their size and fields of activities. The second section explores the actual construction cost control practice. Each question of this section is divided into three parts. The first part involves multiple choice questions, where each question reflects one tool of the cost control practice. The second part is an open-ended one. It highlights the advantages as well as the disadvantages of using each method. The third part aids to evaluate the effectiveness of the tools used by the contractors based on the criteria illustrated in page 26 . In this part a scale from 1 to 7 is used where:

1= Not effective and 7= Very effective

The third section explores the effects of the thirty one potential factors on the Frequency of Reporting, Work Breakdown Structure, and Organization Breakdown Structure.

3.2.1 Sample Size:

From the building contractors in the Eastern Province of Saudi Arabia a randomly selected sample was interviewed.

According to the latest publications of the Eastern Province Chamber of Commerce, the number of building contractors registered for the period 1410-1411 is 605.

The sample size to conduct this study was determined from the following formula: (38)

$$n = n_o / [1 + n_o / N] \qquad \{9\}$$

Where:-

n = Sample size
$n_o = (t^2Pq) / d^2$
N = Population Size
t = $t(\alpha/2)$ is the abscissa of the normal curve that cuts off an area of = 0.05 at the tail. t=1.96
d = The expected error of estimate =0.05
$Pq = S^2$ = The maximum standard deviation in the sampling element.
P = The proportion of the characteristic under investigation. P=0.5 for the maximum sample size.
q = 1-P = 0.5

By substituting in equation 1 and by the iteration process* :

$n_1 = (1.96 * .5/0.05)^2 / [1 + (1.96 * .5 / 0.05)^2 / 605] = 384.16 / 1.64 = 234.96$
$n_2 = 234.96 / [1 + 234.96 / 605] = 169.24$
$n_3 = 169.24 / [1 + 169.24 / 605] = 132.25$
$n_4 = 138.88$
.
.
.
$n_{12} = 48.11$
$n_{13} = 44.57$

---

* Dr. Munir Ahmad, Department of Mathematics, K.F.U.P.M, Dhahran, 1991

Since the difference between n_{12} and n_{13} is small it was decided to stop. So the sample size = 45 contractors.

3.2.2 Sample Selection:

To ensure randomness and unbiased results, the respondents of this study were selected using the table of random numbers as follows:-

1) The list of the building contractors operating in the Eastern Province, obtained from the Eastern Province Chamber of Commerce, was sequentially numbered.
2) Using the tables of random numbers, the corresponding contractors were selected accordingly.
3) By using the table of random numbers, the sample was ascertained to reflect exactly the characteristics of the whole population. However, since the list prepared by the Chamber of Commerce includes the maintenance and specialized building subcontractors as well, the selected respondents were first contacted to ascertain that they practiced building construction. During the selection process, some selected contractors were found to work only in maintenance and/or finishing work. These contractors were ignored and substituted using the tables of random numbers again.

By following the above procedures, independence, randomness and representativeness of the sample selection was assured (39).

3.2.3 Interview Sessions:

During sampling process, the selected contractors were phoned to get their addresses and working hours.

For each contractor, the first person to contact was the project manager or the responsible engineer to explain to him the objectives of the research, and in turn assign the right person to be interviewed. By this procedure the following were guaranteed:-

1) The interviewee had the required knowledge to attain the objectives of the research.
2) The interviewee was willing to spend the time required to conduct the interview.

Average interview time ranged between two to three hours. However, some interviewees were not able to spend this time continuously. In these cases, the interviews were held in two sessions.

Some of the contractors could not afford to spend this time, and refused to conduct these sessions. In this situation, if the contractor - to the best knowledge of the researcher and his colleagues - was known to have a

cooperative attitude with the researchers, he was given the questionnaire to fill alone. To ensure accurate results in these situations, the respondents were thoroughly instructed how to answer each part of the questions. The respondents were also given the researcher's phone number to clarify any difficulties encountered. A total of ten contractors answered the interview schedule in this manner.

When collecting the questionnaires, short discussions were held with the respondents to get their feedback about the questions and to ensure full understanding of the questions and precision in answers.

During the interview session, two copies of the interview schedule were used; one for the respondent to fill and one for the researcher to follow the respondent while answering the questions. Before answering any question - specially for part 2 of the questions - thorough discussions were held with the contractors regarding the tools used to control construction cost. The aim behind these discussions was to clarify any ambiguity the contractor might face while answering the questions, as well as expanding the researcher's awareness regarding the tools used.

3.3 DATA ANALYSIS:

In this research quantitative as well as qualitative analysis were conducted. Data were analyzed using Statistical Analysis System "SAS", which is a package available at King Fahd University of Petroleum and Minerals (K.F.U.P.M.) mainframe.

CHAPTER 4

RESULTS AND ANALYSIS

This chapter delineates the findings of this research regarding cost control practice as well as the factors that affect the exerted level of control.

Data obtained from this study was analysed by stratifying the contractors five grades specified by the Agency of Classification of Contractors, Ministry of Public Works and Housing in Riyadh.

According to the agency, the contractors are classified on the basis of job size into five grades as follows:-

Grade	Max. job size (millions of SR.)
5(Highest grade number)	5
4	15
3	50
2	200
1(lowest grade number)	over 200

The rationale behind this stratification is that, since the grades are based on the maximum job sizes that can be handled by the contractors, it is expected that the contractors of low grade numbers implement better cost control practice than the contractors of high grade numbers.

The sample distribution across the grades is as follows:

Grade	Sample Size
5(highest grade number)	19
4	12
3	5
2	3
1(lowest grade number)	6

Information regarding the contractors firms is summarized in Appendix B. This information will help in analyzing the findings of this study.

This chapter is divided into two sections. The first section presents the tools of construction cost control that are utilized by the Saudi contractors to control their project costs. The second section presents the factors that affect the level of control.

4.1 CONSTRUCTION COST CONTROL:

This section discusses the tools used by the contractors to control cost during construction.

It was found that these contractors utilize a basic logic sequence in cost control. They start by setting the required budget. This is followed by measuring and reporting the

actual cost. A test of variance is then conducted. Finally, the necessary corrective actions are implemented.

Figures 13 to 17 summarize the construction cost control practice classified according to the contractors grades*[1]. These charts illustrate the tools used in cost control according to their sequence of application. These tools are presented in terms of the percentage of contractors using each tool. However, it should be noted that the summation of the percentages in each block may exceed 100%. This is due to the fact that more than one technique within each tool may be used by the same contractor.

Tables 4 to 19 tabulate the percentage of contractors using each tool and the average value of degree of effectiveness of these tools. The reasons for using each tool and the advantages and disadvantages obtained from the interviews were utilized to understand the behavior of the respondents*[2].

---

*[1] This charting technique was adopted from reference 14.

*[2] CAUTIONARY REMARK:
The analysis presented in this research are based on the respondents, opinions and logic, and are not intended to be a judgement on the good cost control practice.

BUDGET SETTING

Project Management

Construction Budgeting

a) Direct Use of Estimator Pricing (83%)
b) Historical Records of Site Data (33.3%)
c) Site Analysis and Subsequent Budgetary Adjustments (33.3%)

Level of Detail of W.B.S.

a) Standard Item Headings Pre-defined at Head-office (50%)
b) Special Work Item Headings (33.3%)
c) Major Structural Components and Locations (33.3%)
d) Main Resources Categories (16.7%)

Cost Codes

a) 46-60 (50%)
b) >60 (50%)

Period of Short Term Planning

a) 2-4 Weeks (66.7%)
b) One Week (16.7%)
b) 5-6 Weeks (16.7%)

Perform Work

REPORTING ACTUAL COST

Measure Actual Work

Frequency of Measuring Actual Cost

a) Monthly (83.3%)
b) Weekly (33.3%)

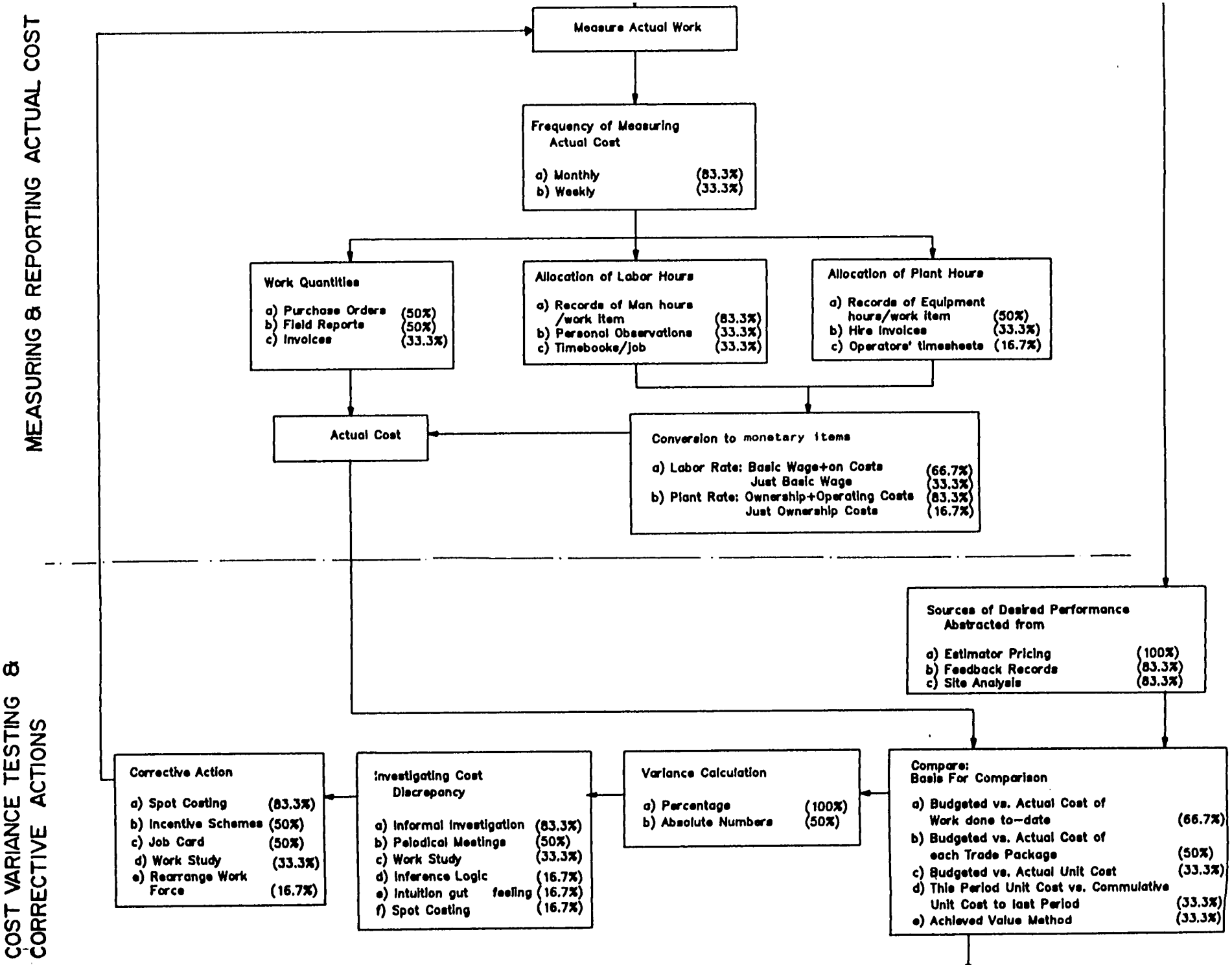
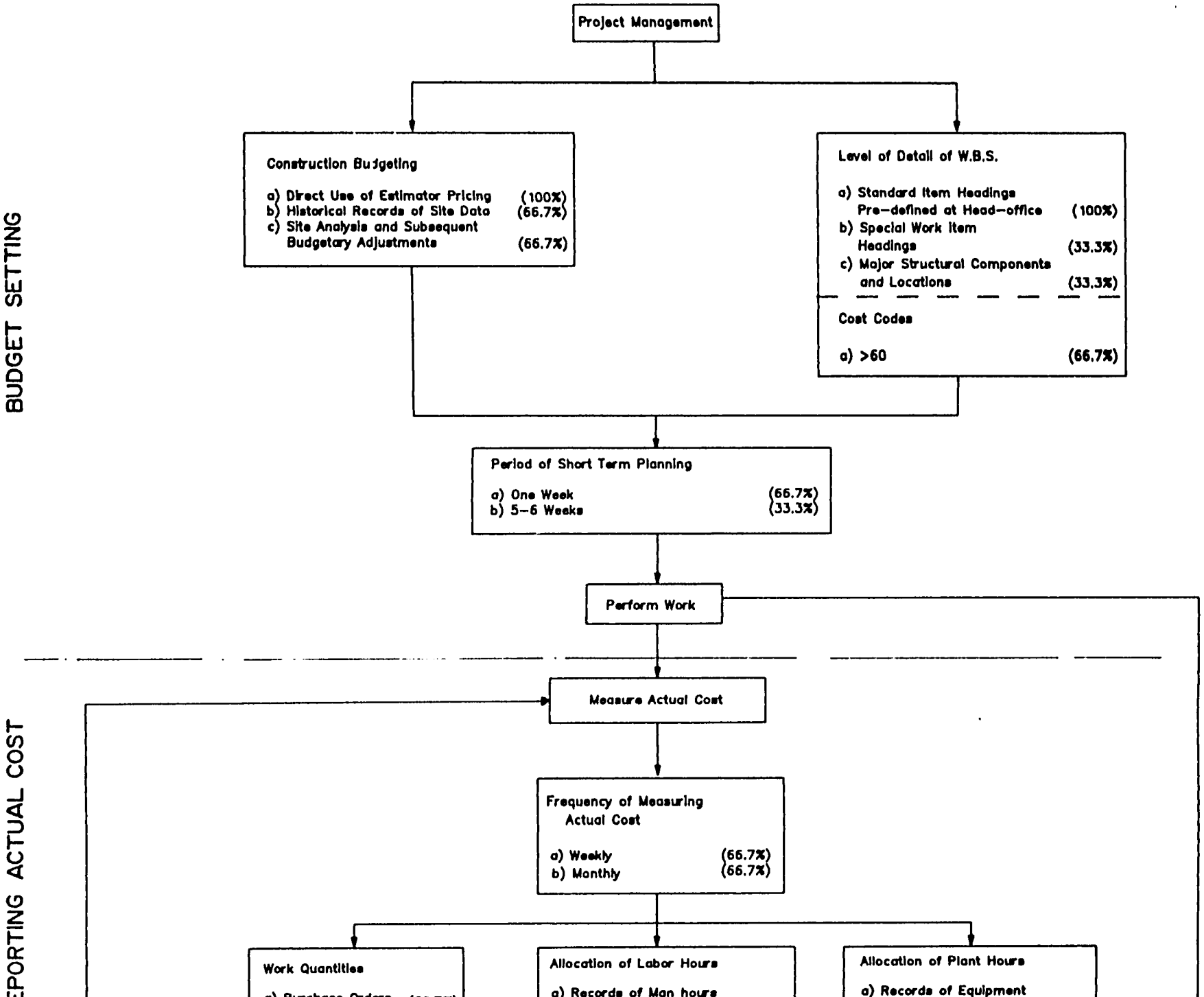


Fig (13): Construction Cost Control Practice For First Grade Contractors


BUDGET SETTING
REPORTING ACTUAL COST
Project Management
Construction Budgeting
a) Direct Use of Estimator Pricing (100%)
b) Historical Records of Site Data (66.7%)
c) Site Analysis and Subsequent Budgetary Adjustments (66.7%)
Level of Detail of W.B.S.
a) Standard Item Headings Pre-defined at Head-office (100%)
b) Special Work Item Headings (33.3%)
c) Major Structural Components and Locations (33.3%)
Cost Codes
a) >60 (66.7%)
Period of Short Term Planning
a) One Week (66.7%)
b) 5-6 Weeks (33.3%)
Perform Work
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Weekly (66.7%)
b) Monthly (66.7%)
Work Quantities
Allocation of Labor Hours
Allocation of Plant Hours
a) Records of Equipment

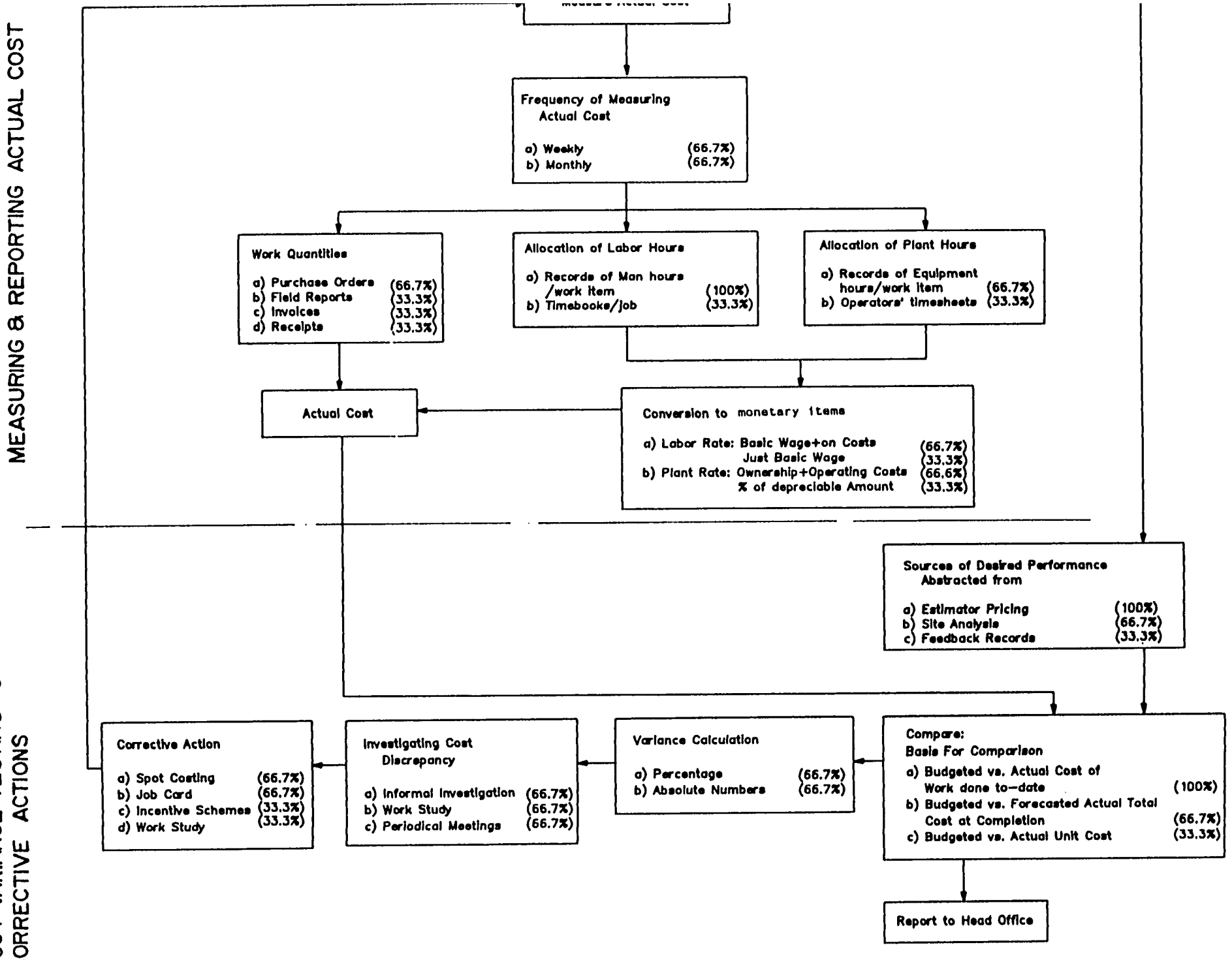
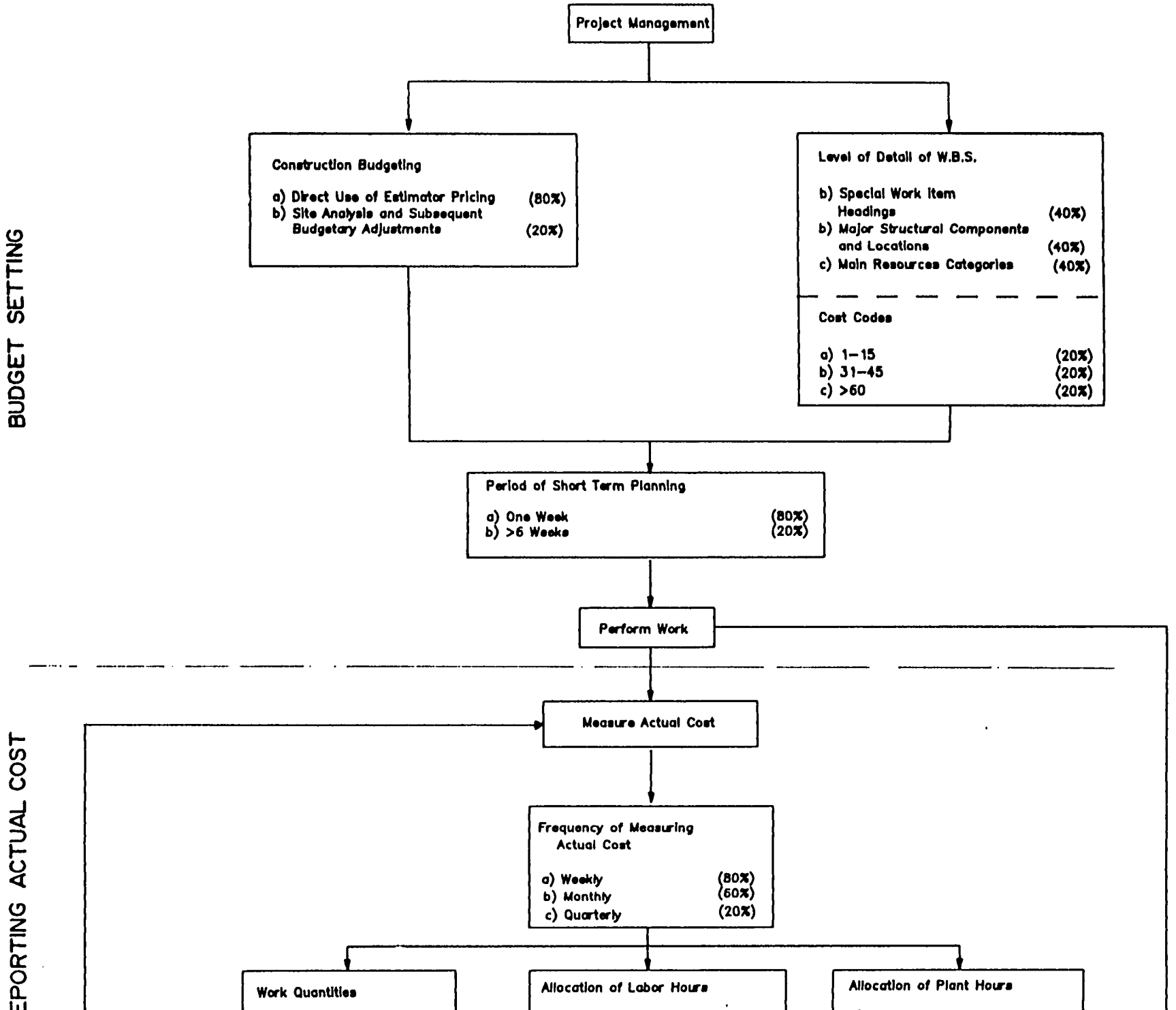
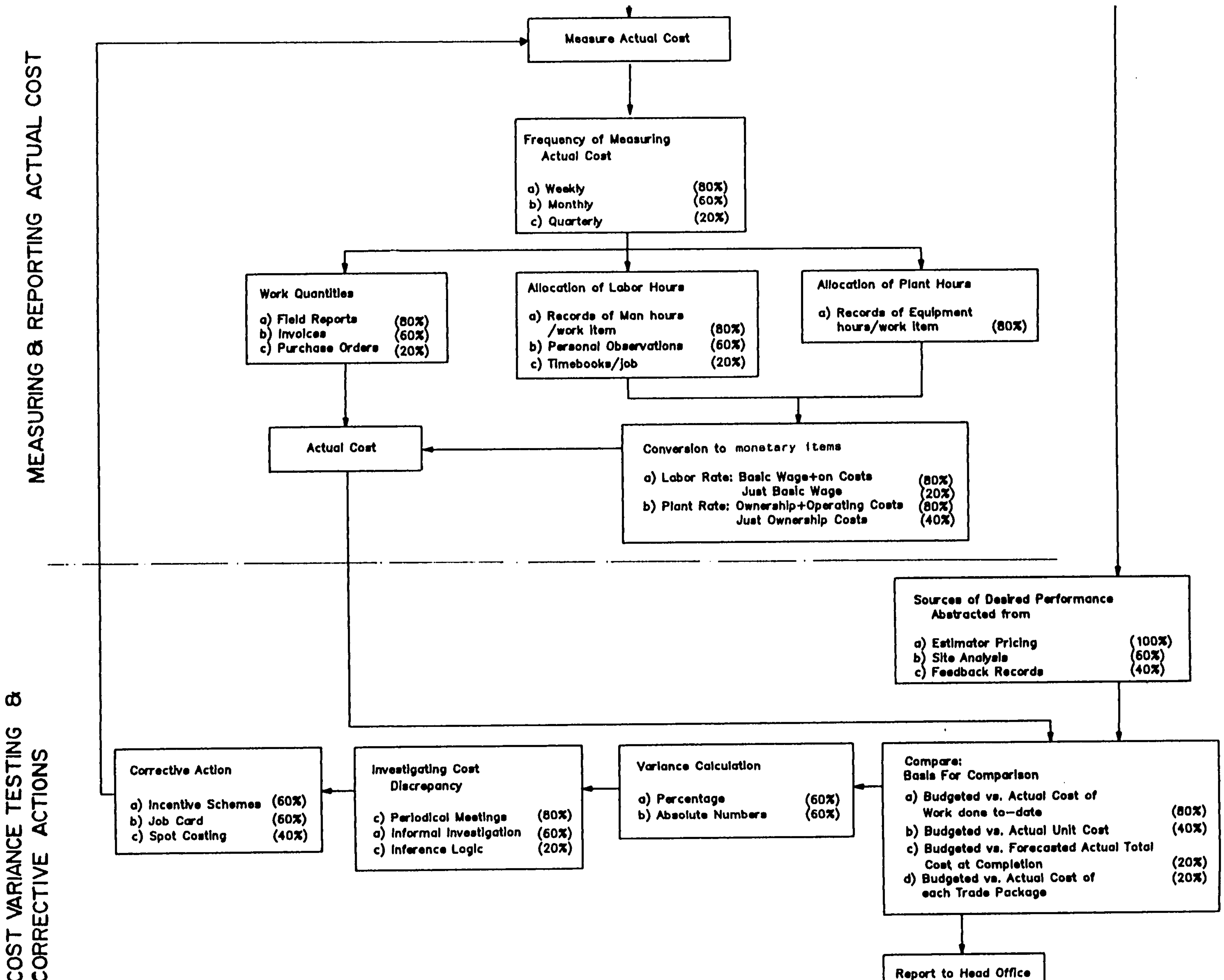
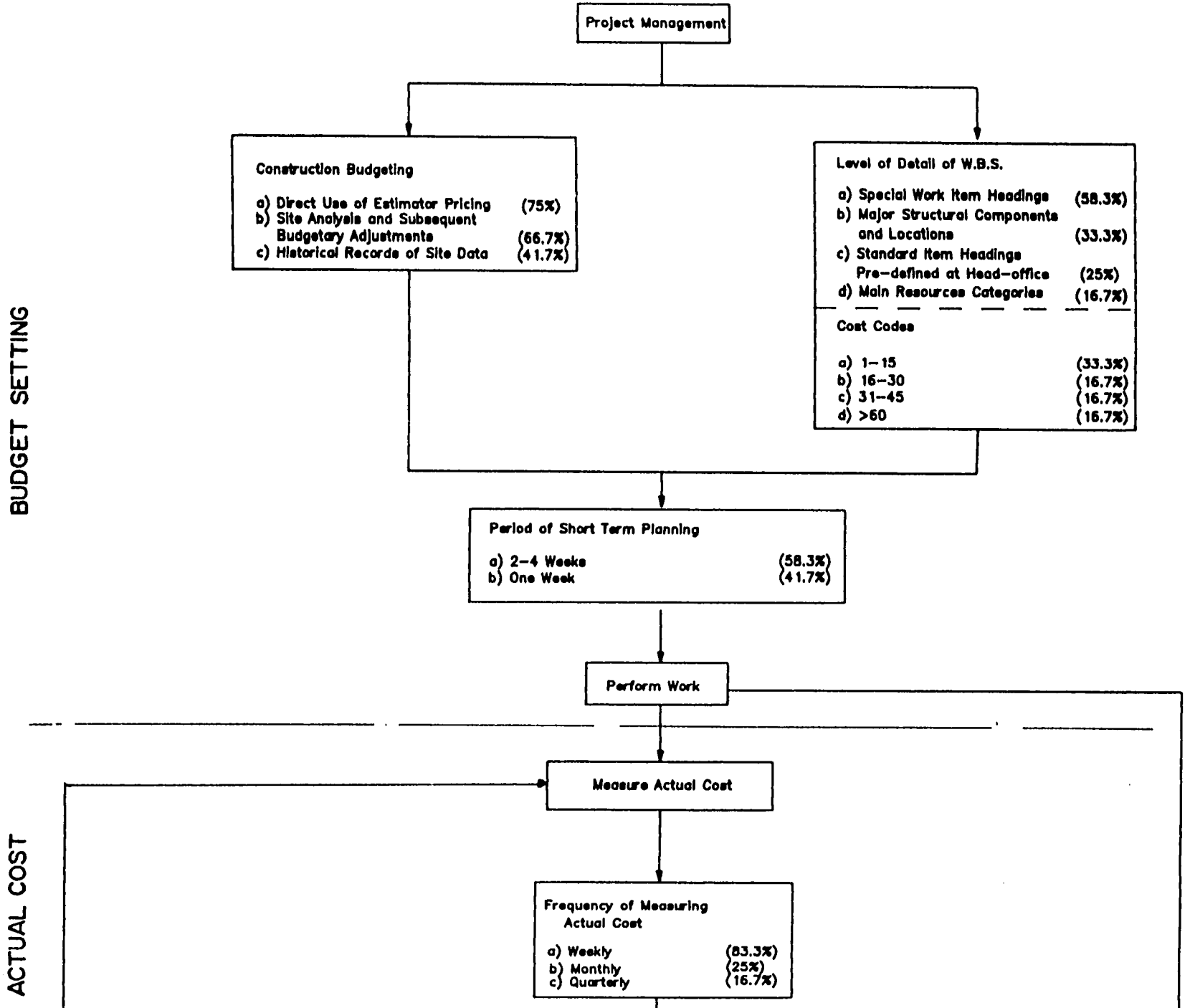
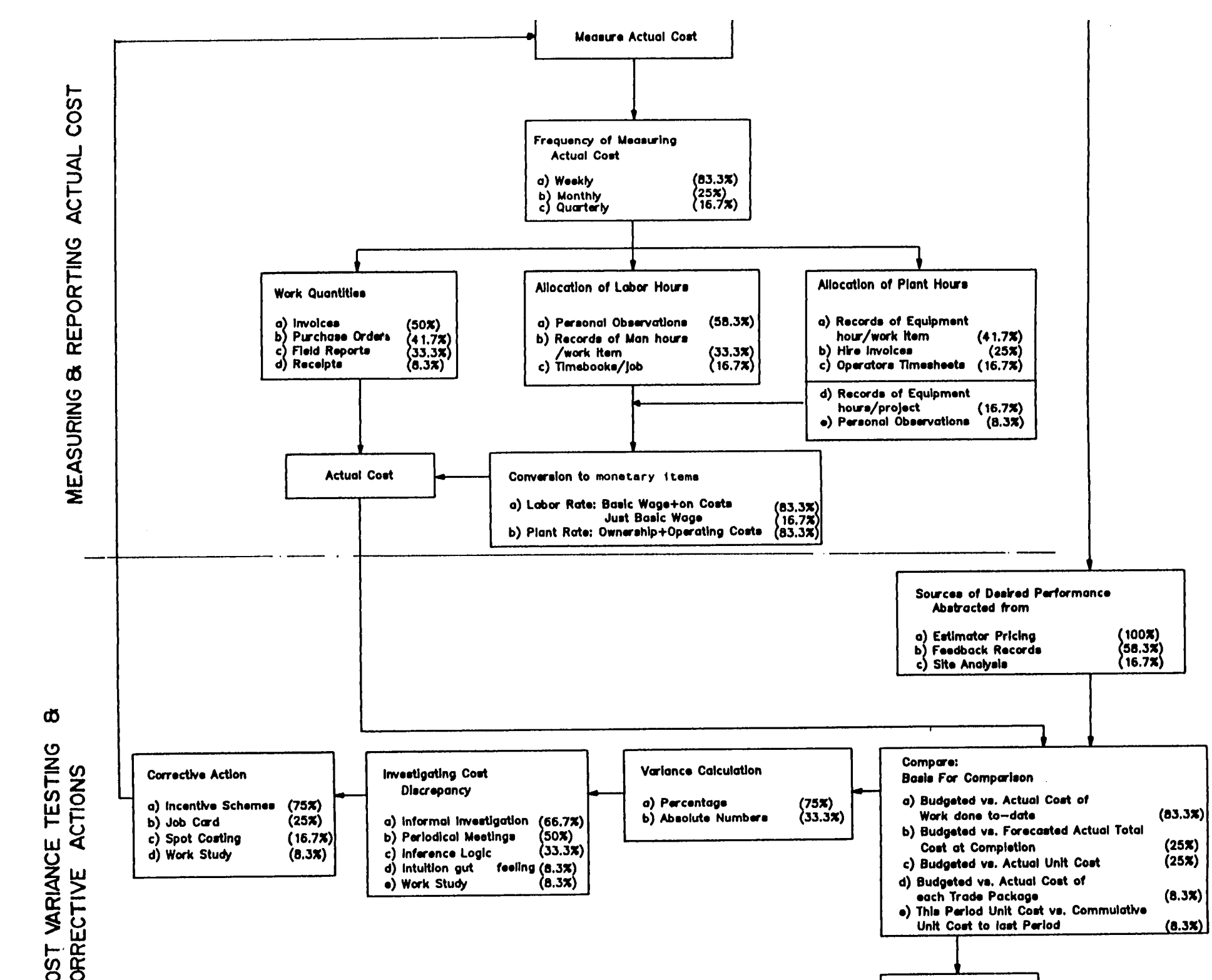


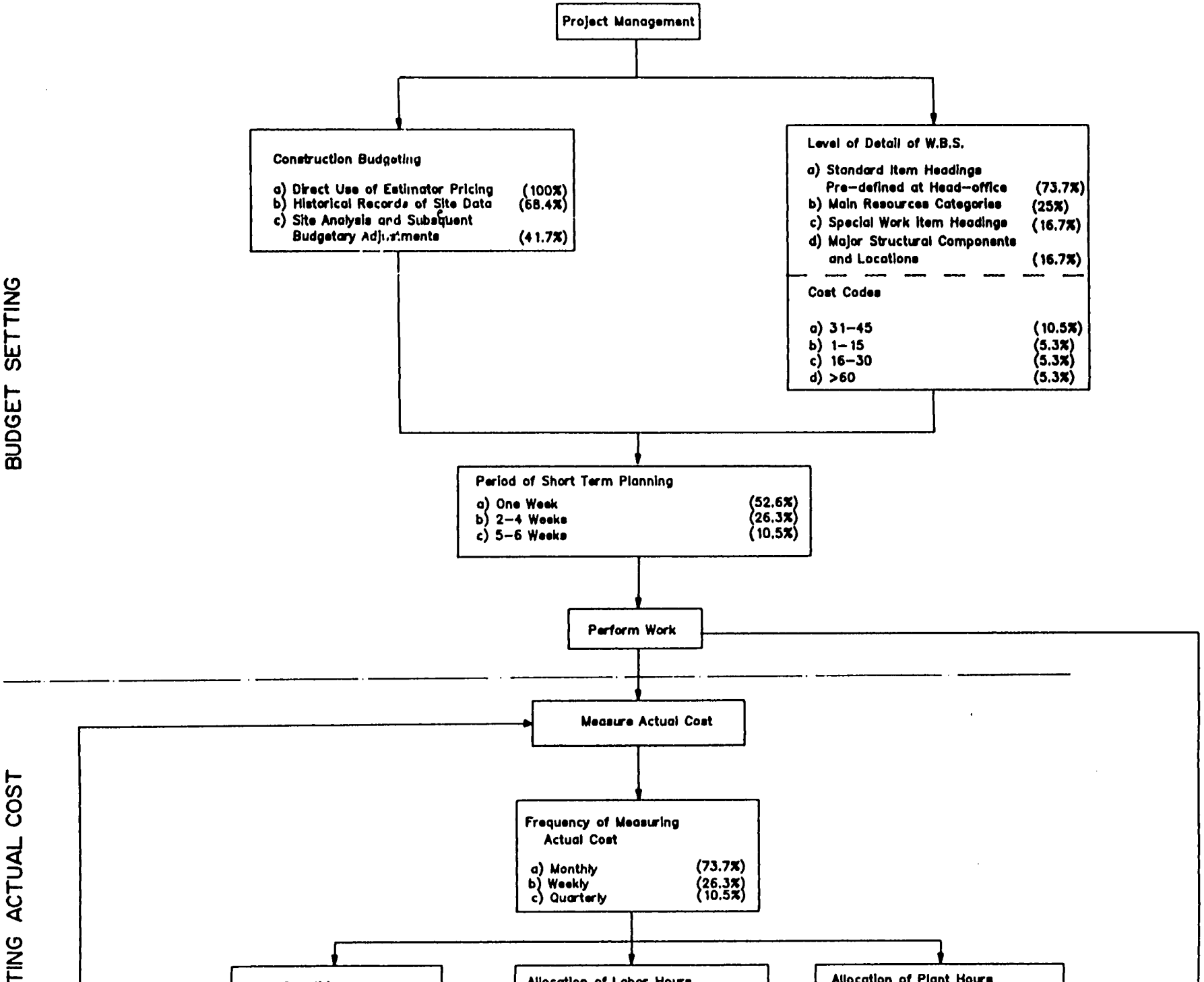
Fig (14): Construction Cost Control Practice For Second Grade Contractors

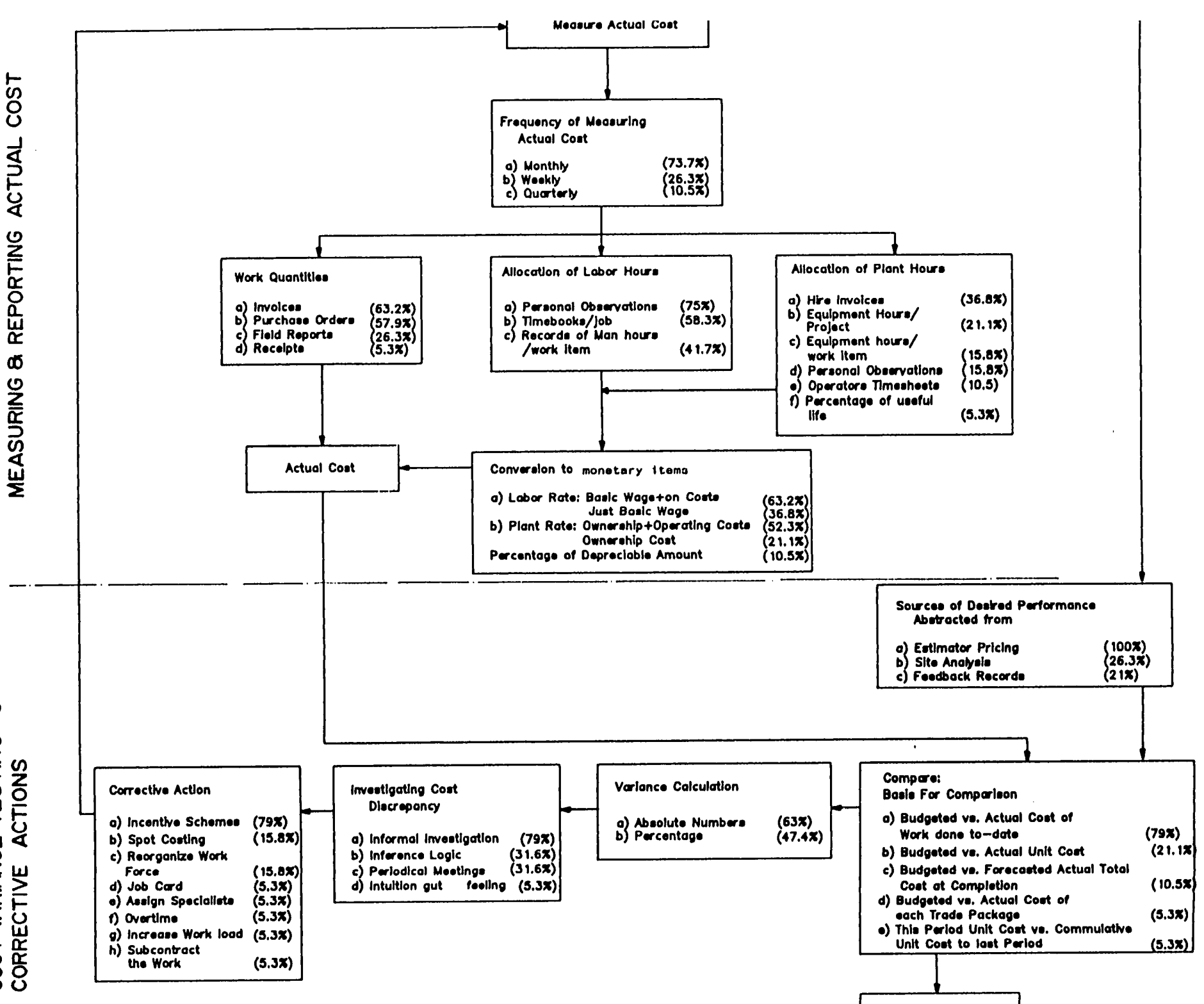

BUDGET SETTING
Project Management
Construction Budgeting
a) Direct Use of Estimator Pricing (80%)
b) Site Analysis and Subsequent Budgetary Adjustments (20%)
Level of Detail of W.B.S.
b) Special Work Item Headings (40%)
b) Major Structural Components and Locations (40%)
c) Main Resources Categories (40%)
Cost Codes
a) 1-15 (20%)
b) 31-45 (20%)
c) >60 (20%)
Period of Short Term Planning
a) One Week (80%)
b) >6 Weeks (20%)
Perform Work
REPORTING ACTUAL COST
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Weekly (80%)
b) Monthly (60%)
c) Quarterly (20%)
Work Quantities
Allocation of Labor Hours
Allocation of Plant Hours


MEASURING & REPORTING ACTUAL COST
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Weekly (80%)
b) Monthly (60%)
c) Quarterly (20%)
Work Quantities
a) Field Reports (80%)
b) Invoices (60%)
c) Purchase Orders (20%)
Allocation of Labor Hours
a) Records of Man hours /work item (80%)
b) Personal Observations (60%)
c) Timebooks/job (20%)
Allocation of Plant Hours
a) Records of Equipment hours/work item (80%)
Actual Cost
Conversion to monetary items
a) Labor Rate: Basic Wage+on Costs (80%)
Just Basic Wage (20%)
b) Plant Rate: Ownership+Operating Costs (80%)
Just Ownership Costs (40%)
COST VARIANCE TESTING & CORRECTIVE ACTIONS
Sources of Desired Performance Abstracted from
a) Estimator Pricing (100%)
b) Site Analysis (60%)
c) Feedback Records (40%)
Compare:
Basis For Comparison
a) Budgeted vs. Actual Cost of Work done to-date (80%)
b) Budgeted vs. Actual Unit Cost (40%)
c) Budgeted vs. Forecasted Actual Total Cost at Completion (20%)
d) Budgeted vs. Actual Cost of each Trade Package (20%)
Variance Calculation
a) Percentage (60%)
b) Absolute Numbers (60%)
Investigating Cost Discrepancy
c) Periodical Meetings (80%)
a) Informal Investigation (60%)
c) Inference Logic (20%)
Corrective Action
a) Incentive Schemes (60%)
b) Job Card (60%)
c) Spot Costing (40%)
Report to Head Office


BUDGET SETTING
ACTUAL COST
Project Management
Construction Budgeting
a) Direct Use of Estimator Pricing (75%)
b) Site Analysis and Subsequent Budgetary Adjustments (66.7%)
c) Historical Records of Site Data (41.7%)
Level of Detail of W.B.S.
a) Special Work Item Headings (58.3%)
b) Major Structural Components and Locations (33.3%)
c) Standard Item Headings Pre-defined at Head-office (25%)
d) Main Resources Categories (16.7%)
Cost Codes
a) 1-15 (33.3%)
b) 16-30 (16.7%)
c) 31-45 (16.7%)
d) >60 (16.7%)
Period of Short Term Planning
a) 2-4 Weeks (58.3%)
b) One Week (41.7%)
Perform Work
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Weekly (83.3%)
b) Monthly (25%)
c) Quarterly (16.7%)


MEASURING & REPORTING ACTUAL COST
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Weekly (83.3%)
b) Monthly (25%)
c) Quarterly (16.7%)
Work Quantities
a) Invoices (50%)
b) Purchase Orders (41.7%)
c) Field Reports (33.3%)
d) Receipts (8.3%)
Allocation of Labor Hours
a) Personal Observations (58.3%)
b) Records of Man hours /work item (33.3%)
c) Timebooks/Job (16.7%)
Allocation of Plant Hours
a) Records of Equipment hour/work item (41.7%)
b) Hire Invoices (25%)
c) Operators Timesheets (16.7%)
d) Records of Equipment hours/project (16.7%)
e) Personal Observations (8.3%)
Actual Cost
Conversion to monetary items
a) Labor Rate: Basic Wage+on Costs (83.3%)
Just Basic Wage (16.7%)
b) Plant Rate: Ownership+Operating Costs (83.3%)
Sources of Desired Performance Abstracted from
a) Estimator Pricing (100%)
b) Feedback Records (58.3%)
c) Site Analysis (16.7%)
COST VARIANCE TESTING & CORRECTIVE ACTIONS
Compare:
Basis For Comparison
a) Budgeted vs. Actual Cost of Work done to-date (83.3%)
b) Budgeted vs. Forecasted Actual Total Cost at Completion (25%)
c) Budgeted vs. Actual Unit Cost (25%)
d) Budgeted vs. Actual Cost of each Trade Package (8.3%)
e) This Period Unit Cost vs. Commulative Unit Cost to last Period (8.3%)
Variance Calculation
a) Percentage (75%)
b) Absolute Numbers (33.3%)
Investigating Cost Discrepancy
a) Informal Investigation (66.7%)
b) Periodical Meetings (50%)
c) Inference Logic (33.3%)
d) Intuition gut feeling (8.3%)
e) Work Study (8.3%)
Corrective Action
a) Incentive Schemes (75%)
b) Job Card (25%)
c) Spot Costing (16.7%)
d) Work Study (8.3%)


BUDGET SETTING
Project Management
Construction Budgeting
a) Direct Use of Estimator Pricing (100%)
b) Historical Records of Site Data (68.4%)
c) Site Analysis and Subsequent Budgetary Adjustments (41.7%)
Level of Detail of W.B.S.
a) Standard Item Headings Pre-defined at Head-office (73.7%)
b) Main Resources Categories (25%)
c) Special Work Item Headings (16.7%)
d) Major Structural Components and Locations (16.7%)
Cost Codes
a) 31-45 (10.5%)
b) 1-15 (5.3%)
c) 16-30 (5.3%)
d) >60 (5.3%)
Period of Short Term Planning
a) One Week (52.6%)
b) 2-4 Weeks (26.3%)
c) 5-6 Weeks (10.5%)
Perform Work
TING ACTUAL COST
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Monthly (73.7%)
b) Weekly (26.3%)
c) Quarterly (10.5%)


MEASURING & REPORTING ACTUAL COST
COST VARIANCE TESTING & CORRECTIVE ACTIONS
Measure Actual Cost
Frequency of Measuring Actual Cost
a) Monthly (73.7%)
b) Weekly (26.3%)
c) Quarterly (10.5%)
Work Quantities
a) Invoices (63.2%)
b) Purchase Orders (57.9%)
c) Field Reports (26.3%)
d) Receipts (5.3%)
Allocation of Labor Hours
a) Personal Observations (75%)
b) Timebooks/Job (58.3%)
c) Records of Man hours /work item (41.7%)
Allocation of Plant Hours
a) Hire Invoices (36.8%)
b) Equipment Hours/ Project (21.1%)
c) Equipment hours/ work item (15.8%)
d) Personal Observations (15.8%)
e) Operators Timesheets (10.5)
f) Percentage of useful life (5.3%)
Actual Cost
Conversion to monetary items
a) Labor Rate: Basic Wage+on Costs (63.2%)
Just Basic Wage (36.8%)
b) Plant Rate: Ownership+Operating Costs (52.3%)
Ownership Cost (21.1%)
Percentage of Depreciable Amount (10.5%)
Sources of Desired Performance Abstracted from
a) Estimator Pricing (100%)
b) Site Analysis (26.3%)
c) Feedback Records (21%)
Compare:
Basis For Comparison
a) Budgeted vs. Actual Cost of Work done to-date (79%)
b) Budgeted vs. Actual Unit Cost (21.1%)
c) Budgeted vs. Forecasted Actual Total Cost at Completion (10.5%)
d) Budgeted vs. Actual Cost of each Trade Package (5.3%)
e) This Period Unit Cost vs. Commulative Unit Cost to last Period (5.3%)
Variance Calculation
a) Absolute Numbers (63%)
b) Percentage (47.4%)
Investigating Cost Discrepancy
a) Informal Investigation (79%)
b) Inference Logic (31.6%)
c) Periodical Meetings (31.6%)
d) Intuition gut feeling (5.3%)
Corrective Action
a) Incentive Schemes (79%)
b) Spot Costing (15.8%)
c) Reorganize Work Force (15.8%)
d) Job Card (5.3%)
e) Assign Specialists (5.3%)
f) Overtime (5.3%)
g) Increase Work load (5.3%)
h) Subcontract the Work (5.3%)

4.1.1 BUDGET SETTING:

One of the first steps in cost control is to break down the project into its constituent activities and assign a budget to each activity. These activities are related to the assigned budget by means of cost codes. These budgeted activities are continuously planned ahead of every specific period of time. At the end of each period, the project cost status is evaluated and updated by project management.

4.1.1.1 Methods of Work Breakdown Structure:

Table 4 presents the methods used by the contractors to break down the work into its relevant activities. According to this table, the majority of the contractors (58%) use either standard item headings pre-defined at head office (dividing the work in standard components and locations, like all brick work), or work item headings specially tailored to project W.B.S.

In addition to the above two methods, the first grade contractors also divide the work into the major structural components and locations. However, a very small percentage depend on a fourth method in combination with the above three, which is dividing the work into main resources per period (plant, material ... etc.). For this grade, standard item headings seem most effective.

Table 4 : Methods of Work Breakdown Structure for Site Use.

		Contractor Grade					
		5	4	3	2	1	Total
Method # 1	No.	12	1	0	1	2	16
	%	63.2%	8.3%	0.0%	33.3%	33.3%	35.6%
	Effect.	6.5	5.0	-	5.0	6.5	
2	No.	2	5	2	0	1	10
	%	10.5%	41.7%	40.0%	0.0%	16.7%	22.2%
	Effect.	5.5	5.8	6.0	-	5.0	
3	No.	1	2	1	0	2	6
	%	5.3%	16.7%	20.0%	0.0%	33.3%	13.3%
	Effect.	5.0	5.5	6.0	-	3.5	
4	No.	2	0	1	0	0	3
	%	10.5%	0.0%	20.0%	0.0%	0.0%	6.7%
	Effect.	3.0	-	3.0	-	-	
1 & 2	No.	0	1	0	1	0	2
	%	0.0%	8.3%	0.0%	33.3%	0.0%	4.4%
	Effect.	-	6.0	-	6.0	-	
1 & 3	No.	1	1	0	1	0	3
	%	5.3%	8.3%	0.0%	33.3%	0.0%	6.7%
	Effect.	5.0	6.0	-	5.0	-	
1 & 4	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	6.0	-	-	-	-	
2 & 4	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	4.0	-	-	-	
3 & 4	No.	0	1	1	0	0	2
	%	0.0%	8.3%	20%	0.0%	0.0%	4.4%
	Effect.	-	5.0	5.0	-	-	
1 & 2 3 & 4	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	6.0	
Total		19	12	5	3	6	45

A) Methods:
1. Standard Item Headings Pre-defined at Head Office.
2. Work Item Headings Specially Tailored to Project W.B.S.
3. Division of Work into Major Structural Components and Locations.
4. Division of Work into Main Resources Categories Per-period.

B) Effect. : Degree of effectiveness (average response on a scale from 1 (min.) to 7 (max.).

The second grade contractors are observed to depend on using standard item headings either alone or combined with other methods. For these contractors, using a combination of standard as well as special item headings is most effective.

40% or more of the third and fourth grade contractors (two out of five in the third grade and five out of twelve in the fourth grade) depend on special work item headings. However, the rest fluctuate and are scattered among the other methods or a combination of them. In the third grade contractors, special work item headings and dividing the work into major structural components and locations are of equal effectiveness. However, the first is more popular. In the fourth grade contractors, combining standard and special item headings is of equal effectiveness to combining the standard item headings with the major structural components and locations. Both methods are the most effective for this grade. However, this degree of effectiveness is indicated by only one contractor in each grade.

For the fifth grade contractors, a heavy dependence on standard item headings is noticed. In addition, this method seems most effective.

According to the contractors, the reasons behind the popularity of using standard item headings are as follows:

1) The first grade contractors depend on these standard items to unify the procedure among their branches inside and outside the Kingdom. By feeding these standard items into the computers, communication between the head office and the branches becomes easier. A very important point should be noticed that most of the contractors in this grade are not Saudis and their head offices are outside the Kingdom.
2) For the contractors of higher grade number (specially the fifth), this method looks popular and effective due to its simplicity. Most of the projects handled by this grade are villas or commercial projects of typical nature. As a result, project personnel became well acquainted with these types of projects and their problems.
3) Using this typical procedure, it is possible to handle the maximum number of projects with the available number of employees.
4) This method coincides with projects specification breakdown.

In spite of these advantages, the contractors indicated the following drawbacks:

1) This method lacks flexibility in use which may not suit some projects types. This disadvantage is more pronounced for the contractors of lower grade numbers, where different types of projects are handled.
2) Most of the higher grade number contractors ignore many special details and the break down of material and labor.

Using special item headings is very effective in achieving the special needs of the projects handled. However the contractors declared the following disadvantages:

1) It is expensive to implement. This expense is due to raising the project and office overhead cost required to conduct new studies for W.B.S. for each project alone.
2) The contractors who use this method complain of the lack of standardization of item headings during project analysis, which in turn makes it difficult to compare the projects handled.
3) This method lacks flexibility where totally new studies should be conducted to break down the activities of the project.

The main advantages achieved by dividing the work into major structural components and locations is the ease of implementation, specially for large scale projects. In addi-

tion, it helps contractors to understand the relationship among the project components. However, the main disadvantage in utilizing this method is negligence in itemizing the job. For example, all the concrete work done in one part of the lot is treated as one unit without further subdividing the work into smaller units, such as walls, slabs...etc.

Very few contractors (three out of forty five) divide the work into the main resources per period. These contractors are mainly concerned with the overall spending without getting into the details.

For the contractors who combine the above methods, methods 1 & 3 are the most common. Their reason for this combination is to use a standard format while focusing on the relationships among the project components.

A general conclusion was drawn from the interviews that the high grade number contractors -specially the fifth grade- use their present methods because they are not fully aware of the other options. On the other hand, in the low grade number contractors -specially the first grade- the project personnel are forced to use specific methods because it is part of the company policy. Some of these contractors are foreign companies - as was mentioned earlier - where these methods were formulated in their head office and applied unchanged in Saudi Arabia.

4.1.1.2 Codes of Accounts:

Cost codes are alpha-numeric codes that combine the work and the organization breakdown structure with the relevant financial information. This labelling system helps in identifying what and where the item is, what is being done to the item, and who is responsible for the action (5,17).

The results of the survey indicate the majority of the contractors do use cost codes. However, a large percentage (approximately 40%) do not utilize these codes (Table 5).

Because of the big size of projects handled, half (three out of six) of the first grade contractors use more than 60 cost codes, and even up to more than 300. However, the other half use between 31-45 codes. Their justification for this range is to allow concentration on the major items of work.

From Table 5 it is noticed that the contractors of higher grade numbers use a smaller number of cost codes than the contractors of lower grade numbers. However, an important finding is that, except for the first grade contractors, a high percentage do not utilize codes of accounts. It is further surprising that most of the fifth grade contractors were found not to be aware of what cost codes are. So a lack of knowledge of the concept of cost codes is a noticeable feature.

The first, second and third grade contractors agree on the effectiveness of utilizing more than 60 cost codes. However using 1-15 cost codes seems more effective for fourth and fifth grade contractors. However, this degree of effectiveness was indicated by two contractors out of nineteen in the fourth grade and four out twelve in the fourth.

Table 5 : No. and Effectiveness of Cost Codes Utilized.

		Contractor Grade					
		5	4	3	2	1	Total
Not Used	No.	14	2	2	1	0	19
	%	73.7%	16.7%	40.0%	33.3%	0.0%	42.2%
	Effect.	-	-	-	-	-	
1 - 15	No.	2	4	1	0	0	6
	%	10.5%	33.3%	20.0%	0.0%	0.0%	13.3%
	Effect.	6.0	6.5	5.0	-	-	
16 - 30	No.	1	2	0	0	0	3
	%	5.3%	16.7%	0.0%	0.0%	0.0%	6.7%
	Effect.	4.0	4.5	-	-	-	
31 - 45	No.	1	2	1	0	3	8
	%	5.3%	16.7%	20.0%	0.0%	50.0%	17.8%
	Effect.	5.0	5.0	5.0	-	4.3	
46 - 60	No.	0	0	0	0	0	0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Effect.	-	-	-	-	-	
> 60	No.	1	2	1	2	3	9
	%	5.3%	16.7%	20.0%	66.7%	50.0%	20.0%
	Effect.	4.0	5.0	6.0	5.5	6.7	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

According to the interviewees, the main advantages of using cost codes are:

1) A good technique to relate the quantity of the work done, equipment used and personnel with the financial reports.
2) A good check on the losing activities of the project.
3) Specialized services are distinguished from other construction or finishing work.

The main disadvantages experienced by the contractors in using cost codes are as follows:

1) More office and project overhead is required to collect, analyze and report the data.
2) Additional staff may be required to analyze the data. This fact is against the interest of small contractors where they try to keep the minimum number of employees under payroll.
3) For detailed codes, computerized system may be needed which many contractors can not afford.

4.1.1.3 Budget Allocation:

During construction, the budget allocated to different activities and phases of the project can be quantified using three main sources: estimator price, historical records and site analysis. However, Table 6 shows the high dependence on estimator pricing, either alone or combined with one or both of the other two sources.

Table 6 : Budget Allocation.

		Contractor Grade					
		5	4	3	2	1	Total
Estimator Price	No.	3	2	4	0	3	12
	%	15.8%	16.7%	80.0%	0.0%	50.0%	26.7%
	Effect.	3.0	4.5	4.0	-	4.3	
Historical Records	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	6.0	-	-	-	
Site Analysis	No.	0	2	1	0	1	4
	%	0.0%	16.7	20.0%	0.0%	16.7%	8.9%
	Effect.	-	5.5	5.0	-	5.0	
Est. Price + Hist. Records	No.	11	1	0	1	1	14
	%	57.9%	8.3%	0.0%	33.3%	16.7%	31.1%
	Effect.	5.7	7.0	-	4.0	4.0	
Est. Price + Site Analysis	No.	3	3	0	1	0	7
	%	15.8%	25.0%	0.0%	33.3%	0.0%	15.6%
	Effect.	5.0	6.3	-	5.0	-	
Est. Price + Hist. Records Site Analysis	No.	2	3	0	1	1	7
	%	10.5%	25.0%	0.0%	33.3%	16.7%	15.6%
	Effect.	5.0	5.0	-	6.0	7.0	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

Relying on the estimator prices alone has the advantage of using only what was reserved for each part or work item of the project. However, it may result in a high loss due to unforeseen site conditions that may cause over-spending. Due to lack of finance, this part of the project may be even frozen.

Using the estimator pricing along with the site analysis and historical site data has the advantage of more realistic and accurate prediction of cash flow. Using this technique, the computed budget may be less or more than the original budget. A reconciliation of the original budget is then essential.

For the first grade contractors, a high dependence on estimator pricing alone is noticed. This phenomenon may be due to having the head office outside the Kingdom, as was mentioned above. However, one contractor declared that because of conducting the projects estimates abroad, these estimates are based on unrealistic assumptions.

despite the popularity of using estimator pricing alone among the first grade contractors, using the three methods together has the highest degree of effectiveness. However, this degree of effectiveness was indicated by only one out of six respondents. This contractor who depends on this combination can study the special needs of the site, learn from past experience and accordingly adjust the estimated budget. If more than the budgeted amount is needed, a proportional adjustment can be made to the other parts or items of the project. However, the tendency of this grade is that, if less than what was budgeted is really needed, no

adjustment is made and the difference is kept as a reserve against any unexpected circumstances.

The second grade contractors are not observed to be highly dependent on any particular tool. However, using the three sources of information together is most effective for one third of this grade contractors (one out of three).

For the third grade contractors, site analysis received the highest rank by 20% (one contractor out of five) of the respondents. The rest of the five respondents (80%) depend on estimator pricing alone. The only justification for this grade to depend solely on this source is that they normally produce reliable estimates based on thorough site analysis which rarely need to be adjusted.

For the fourth and fifth grade contractors using estimator pricing combined with historical records is most effective. Their main justification for this, is that most of the projects they handle are of a similar nature and scope of work so historical records are more effective than analyzing the site during construction. These two sources are the most popular for the fifth grade (eleven out of nineteen). However, no particular method is heavily used by the fourth grade.

4.1.1.4 Period of Short Term Planning:

In spite of the effectiveness of planning the work for the whole duration of the project, this effort should be supplemented by detailed plans, continuously planned ahead and updated after every specific short period of time. These plans combine the work to be done, the personnel involved and the budgeted cost for the coming period.

One week is used by most of the second, third and fifth grade contractors, while a period from two to four weeks is mostly used by the first and the fourth grade. However, all of the five grades agree on the effectiveness of using only one week.

The advantages gained by using one week are as follows:

- One week is short enough to take an immediate action in respect of any cost deviation during this week.
- Tighter control of resources is achieved.

Despite these advantages, all of the respondents complained of the expenses involved in collecting, analyzing and reporting cost data. Such expenses are due to the time spent as well as the number of staff required. Even with the first grade contractors, who use the computer for data analysis and reporting, greater cost is incurred in collecting and processing the results.

Table 7 : Period of Short Term Planning

		Contractor Grade					
		5	4	3	2	1	Total
Not Used	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
	Effect.	-	-	-	-	-	
1 week	No.	10	5	4	2	1	22
	%	52.6%	41.7%	80.0%	66.7%	16.7%	48.9%
	Effect.	7.0	6.0	5.2	6.7	6.0	
2 - 4 weeks	No.	5	7	0	0	4	16
	%	26.3%	58.3%	0.0%	0.0%	67.7%	35.6%
	Effect.	6.0	5.0	-	-	4.2	
5 - 6 weeks	No.	2	0	0	1	1	4
	%	10.5%	0.0%	0.0%	33.3%	16.7%	8.9%
	Effect.	6.0	-	-	6.0	5.0	
> 6 weeks	No.	0	0	1	0	0	1
	%	0.0%	0.0%	20.0%	0.0%	0.0%	2.2%
	Effect.	-	-	2.0	-	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1 (min.) to 7 (max.).

For the period between 2 and 4 weeks the following advantages are reported:

- It allows enough time for resources mobilization to the site and arranging for the needed cash-flow.
- This period was found a good compromise between the cost involved in very short periods of planning and the loss of control due to very long periods.

- This period was found suitable to produce enough work to be analyzed effectively, since the trend of the work cannot be judged on the basis of very short periods of time.

In spite of the above advantages, some contractors criticized this period as being too long to correct serious cost deviations.

The contractors who use a period from 5 to 6 weeks declared the following advantages:

- The first and second grade contractors who use this method are involved in engineering projects which require long periods for short term planning (Appendix B, Table 33).
- Some of the fifth grade contractors work on projects of a discontinuous nature, where the work on one project stops and the resources are shifted to another project.

The contractors who use more than 6 weeks or do not use short term planning at all, justified this by the typical and small nature of the projects handled where a daily site visits are enough.

4.1.2 MEASURING ACTUAL COST:

Actual cost is normally measured by calculating the cost of labor, equipment, and material.

4.1.2.1 Charging Labor Hours:

Labor hours are normally charged by multiplying the hours consumed by the hourly rate of the laborer.

Calculating Labor Hours Consumed:

Table 8 shows the methods followed by the contractors to calculate the labor hours consumed during construction. This table illustrates the fact that the majority of the contractors depend on personal observations and records of man-hours per work item.

The first grade contractors were seen to have a high dependence on recording the man-hours consumed on each work item. However, some contractors in this grade depend on personal observations and time books that record the man-hours consumed for the project as a whole. This practice has the disadvantage of the difficulty in allocating the cost on a detailed basis, specially when the cost deviation is due to poor labor productivity. For this grade, records of man-hours consumed per work item is also the most effective.

Table 8 : Calculating Labor Hours.

Method(s)		Contractor Grade 5	4	3	2	1	Total
1. Personal Observation	No.	7	6	1	0	0	14
	%	36.8%	50.0%	20.0%	0.0%	0.0%	31.1%
	Effect.	4.2	5.0	3.0	-	-	
2. Record of Man-hours/ Work Item.	No.	3	2	1	2	3	11
	%	15.8%	16.7%	20.0%	66.7%	50.0%	24.4%
	Effect.	4.7	5.5	6.0	5.5	7.0	
3. Time Books/ Job.	No.	5	1	0	0	1	7
	%	26.7%	8.3%	0.0%	0.0%	16.7%	15.6%
	Effect.	6.2	6.0	-	-	3.0	
1 & 2	No.	0	0	2	0	1	3
	%	0.0%	0.0%	40.0%	0.0%	16.7%	6.7%
	Effect.	-	-	6.0	-	7.0	
1 & 3	No.	2	1	0	0	0	3
	%	10.5%	8.3%	0.0%	0.0%	0.0%	6.7%
	Effect.	5.0	4.0	-	-	-	
2 & 3	No.	2	2	1	1	0	6
	%	10.5%	16.7%	20.0%	33.3%	0.0%	13.3%
	Effect.	6.0	3.5	5.0	7.0	-	
1 & 2 & 3	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	5.0	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.)

On the other extreme, the fourth and fifth grade contractors are mainly dependent on personal observation. This approach suffers from the disadvantage of subjectivity in judgement and data manipulation, in addition to the lack of reliable documents to refer to in case of any cost problem.

despite the popularity of using personal observations, relying on time books per work item was indicated as most effective by the minority (one in the fourth and five in the fifth).

Costing Labor Hours:

Two basic approaches are mainly followed to cost labor hours. In the first approach, the labor hour cost is calculated by adding the basic wage and the add-on costs. Such add-on costs include housing, food, transportation and other allowances. In the second method, only the basic wage is considered, while the add-on costs are treated as an overhead.

Table 9 shows the majority of all the contractors in general as well as of each particular grade use the first method.

A very important point can be noticed is that although they use the basic wage plus the add-on costs, the first, second, third and fourth grad contractors believe that using only the basic wage is superior. For these contractors, the methods used are formulated by the company management and used unchanged by the engineers. This feature is more dominant in the first grade contractors where many of them have

their management - which have the authority to make these decisions - in their home countries outside Saudi Arabia.

Table 9 : Costing Labor Hours.

Method(s)		Contractor Grade 5	4	3	2	1	Total
Basic wage + On Costs.	No.	12	10	4	2	4	32
	%	63.2%	83.3%	80.0%	66.7%	66.7%	71.1%
	Effect.	5.5	5.0	4.8	5.0	5.0	
Basic Wage	No.	7	2	1	1	2	13
	%	36.8%	16.7%	20.0%	33.3%	33.3%	28.9%
	Effect.	4.7	5.5	6.0	6.0	7.0	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min) to 7(max.).

The fifth grade contractors believe the methods they follow are superior because their organizations are very simple, and normally the responsible engineer is the one who has the authority to make these decisions or at least has access to the project manager to argue about the methods followed.

The contractors who use just the basic wage declared the following advantages:

1. It distinguishes between direct and indirect costs.
2. Because the add-on costs are considered as overhead, overtime is cheaper.

However, using just the basic wage is very disadvantageous for the contractors who treat the add-on cost as a company overhead, where they cannot predict the actual project cost.

4.1.2.2 Charging Equipment Hours:

As with labor, equipment hours are usually charged by multiplying the number of hours consumed by the hourly equipment rate.

Calculating Equipment Hours Consumed:

From Table 10 it can be seen that a record of equipment operating hours for each work item is the most commonly used technique for all contractors.

Analyzing the five grades also reveals a high dependence on itemizing the equipment operating hours for the first, second and third grade contractors. This method is also indicated as the most effective.

For the fourth and fifth grade contractors, less detailed methods (such as records of equipment hours for the whole project) are used. For these two grades a relatively high dependence on hire invoices is also noticed. This is due to their leasing or renting their equipment. However, lack of accuracy is a major shortcoming.

The accuracy in allocating the man-hours spent on each work item justifies the expenses involved. However, for the contractors who rent or lease their equipment, they depend on the hire invoices. The invoices - as stated by the contractors - do not really reflect the real time spent by the equipment operator doing the job. For this reason, some of the contractors use the equipment operators time sheets alone or along with the hire invoices.

For the contractors who are dependent on recording the equipment hours for the project as a whole suffer from the disadvantage of lacking the itemized hours records. This shortcoming makes it impossible to evaluate work productivity as well as to investigate any cost or schedule deviation.

The contractors who depend on their personal observations suffer from the subjectivity and unreliability of the data obtained.

Table 10 : Calculating Equipment Hours.

Method(s)		Contractor Grade 5	4	3	2	1	Total
1.Hire Invoices	No.	4	3	0	0	1	8
	%	21.1%	25.0%	0.0%	0.0%	16.7%	17.8%
	Effect.	4.5	5.0	-	-	1.0	
2.Record of Equip. Hours/ Work Item	No.	1	4	4	2	3	14
	%	5.3%	33.3%	80.0%	66.7%	50.0%	31.1%
	Effect.	6.0	5.2	4.5	5.0	5.7	
3.Operators Time Sheets	No.	0	1	0	1	1	3
	%	0.0%	8.5%	0.0%	33.3%	16.7%	6.7%
	Effect.	-	2.0	-	4.0	5.0	
4.% of Useful Life.	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	4.0	-	-	-	-	
5.Record of Equip. Hours (whole project)	No.	4	2	0	0	0	6
	%	21.1%	16.7%	0.0%	0.0%	0.0%	13.7%
	Effect.	4.3	3.5	-	-	-	
6.Personnel Observations.	No.	2	1	0	0	0	3
	%	10.5%	8.3%	0.0%	0.0%	0.0%	6.75
	Effect.	4.5	5.0	-	-	-	
Not Calculated	No.	3	0	1	0	0	4
	%	15.8%	0.0%	20.0%	0.0%	0.0%	8.9%
	Effect.	-	-	-	-	-	
1 & 2	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
	Effect.	5.0	-	-	-	-	
1 & 3	No.	1	0	0	0	1	2
	%	5.3%	0.0%	0.0%	0.0%	16.7%	4.4%
	Effect.	6.0	-	-	-	3.0	
2 & 3	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	6.0	-	-	-	
3 & 6	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	4.0	-	-	-	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min) to 7(max.).

The contractors who depend on distributing the equipment useful life on their projects, explained they do not have enough equipment to justify the expenses of calculating the relevant working hours. They have only a few small pieces of equipment such as compactors. For the same reason some contractors do not calculate equipment hours at all and treat equipment expenses as overhead. However, those contractors admitted that their methods do not give any real indication of the real cost of constructing the project.

Records of equipment hours per work item are the most effective for the fifth grade contractors, while combining these records with operators' time-sheets is most effective for the fourth grade. However, an important point to be noticed is that the most popular methods are not the most effective. The main reason is the tendency of the contractors towards using simple and typical procedure. Furthermore, lack of knowledge as well as the unstable market conditions have additional negative effects on this practice.

Costing Equipment Hours:

Table 11 illustrates the different methods used to cost plant hours. By analyzing this table, the following can be observed:

- Most of the contractors use the owning and operating cost to calculate the hourly cost and it is believed to be the most effective one for each grade. The respondents who use this method described it as very effective in calculating the exact cost of the equipment (precise).
- The contractors who simply use ownership as a direct cost, and treat the operating cost as a site overhead, suffer from the lack of work itemization for the machines.
- Some contractors do not distinguish between owning and operating costs, but instead the depreciable amount is divided into the machine's useful life while any extra paid cost is treated as general overhead. The main reason for using this method is the small percentage of equipment owned. In addition, the equipment is not continuously used where it is used for more than one project at a time. As a result, there is no clear idea about of time spent by the equipment on each project alone and the costs incurred.

A general phenomenon concluded from the interviews is the low level of effort made by the contractors in costing plant hours. This can be partially justified by the heavy dependence in building construction on labor rather than equipment. Consequently, some contractors do not even cost plant hours and treat expenses paid as a general company overhead.

Table 11 : Costing Equipment Hours.

Method(s)		Contractor Grade 5	4	3	2	1	Total
Owning + Operating Cost	No.	10	10	3	2	5	30
	%	52.6%	33.3%	60.0%	66.7%	83.3%	66.7%
	Effect.	5.5	5.0	5.3	5.5	5.4	
Just Owning Cost	No.	4	0	1	0	1	6
	%	21.1%	0.0%	20.0%	0.0%	16.7%	13.3%
	Effect.	5.0	-	5.0	-	5.0	
% of Depreciable Amount	No.	2	0	0	1	0	3
	%	10.5%	0.0%	0.0%	33.3%	0.0%	6.7%
	Effect.	5.0	-	-	4.0	-	
Owning + Oper. & Just Owning	No.	0	0	1	0	0	1
	%	0.0%	0.0%	20.0%	0.0%	0.0%	2.2%
	Effect.	-	-	3.0	-	-	
Not Calculated	No.	3	2	0	0	0	5
	%	15.8%	16.7%	0.0%	0.0%	0.0%	11.1%
	Effect.	-	-	-	-	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min) to 7(max.).

4.1.2.3 Charging Material Consumed:

The first step in calculating the cost of material consumed is to allocate the relevant quantity. For all surveyed contractors, purchase orders, invoices, field reports and receipts are the main sources of information to allocate material consumed during construction.

Table 12 illustrates the relative popularity of using invoices over other sources. However, by analyzing the five different, grades it can be noticed that no particular source is heavily used.

Contractors who depend on purchase orders suffer from the disadvantage of lack of knowledge regarding the exact quantity of material consumed. However, some contractors justified using this source of information by their reasonably accurate estimate of the materials quantities at the tendering stage, or by depending on direct translation of the bills of quantities prepared by the consultant into purchase orders for each stage of the work after adding a specified percentage (usually =10%) as a contingency.

Using invoices has the advantage of showing how much was exactly purchased. However it does not show exactly how much was consumed.

Table 12 : Charging Material Consumption.

Method(s)		Contractor Grade 5	4	3	2	1	Total
Purchase Orders	No.	3	2	0	1	1	7
	%	15.8%	16.7%	0.0%	33.3%	16.7%	15.6%
	Effect.	6.0	5.5	-	5.0	5.0	
Invoices	No.	5	3	1	0	2	11
	%	26.3%	25.0%	20.0%	0.0%	33.3%	24.4%
	Effect.	5.4	5.3	5.0	-	5.5	
Field Quantity Reports	No.	1	3	2	1	1	8
	%	5.3%	25.0%	40.0%	33.3%	16.7%	17.8%
	Effect.	5.0	5.3	5.0	6.0	4.0	
Receipts	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	5.0	-	-	-	
Purchase Orders + Invoices	No.	5	2	0	0	0	7
	%	26.3%	16.7%	0.0%	0.0%	0.0%	15.6%
	Effect.	5.6	5.5	-	-	-	
Purchase Orders + Field Reports	No.	2	0	0	0	2	4
	%	10.5%	0.0%	0.0%	0.0%	33.3%	8.9%
	Effect.	6.0	-	-	-	6.0	
Purchase Orders + Receipts	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	6.0	-	-	-	-	
Invoices + Field Reports	No.	1	0	1	0	0	2
	%	5.3%	0.0%	20.0%	0.0%	0.0%	4.4%
	Effect.	2.0	-	6.0	-	-	
Purchase Orders + Invoices + Field Reports	No.	1	1	1	0	0	3
	%	5.3%	8.3%	20.0%	0.0%	0.0%	6.7%
	Effect.	6.0	5.0	6.0	-	-	
Purchase Orders + Invoices + Receipts	No.	0	0	0	1	0	1
	%	0.0%	0.0%	0.0%	33.3%	0.0%	2.2%
	Effect.	-	-	-	6.0	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

Depending on field quantity reports makes it possible to know exactly how much was received and consumed. This method allows project personnel to implement work study programs by allocating how, when and by whom the material was consumed.

Receipts aid in allocating how much was received in the stores and who received them. On the other hand, using this method alone creates difficulties in furnishing information regarding how much was used for each project alone. In addition, no itemized quantities of materials are available.

Due to the above advantages and disadvantages, some contractors use more than one source of information, so maximum advantages are achieved and minimum disadvantages are suffered.

During the course of interviews, it was observed that the general practice for the first, second and third grade contractors is to acquire more materials than are actually needed. These materials are stored and issued to the site when they are needed. This practice suggests the importance of using field quantity reports.

The fourth and fifth grade contractors, whose projects are small, acquire materials which just satisfy their immediate needs. Small contractors - and specially within the

fifth grade - are characterized by the simplicity in organization structure and high dependence on daily site visits to acquire the materials needed. This fact explains why small contractors ignore field quantity reports.

For the degree of effectiveness, Table 12 gives no clear idea regarding the most effective method for each grade.

4.1.2.4 Calculating Resources Cost:

From Table 13, most of the contractors are noticed to depend on actual costs. Although the contractors described this method as an actual and realistic one, the main reason for using this method is lack of knowledge of the other method of calculating cost: All-in Rates (for more information regarding this method, refer to Chapter 2, Page 12).

Table 13 : Calculating Resources Cost.

Method(s)		Contractor Grade 5	4	3	2	1	Total
All in Rates	No.	0	0	0	1	0	1
	%	0.0%	0.0%	0.0%	33.3%	0.0%	2.2%
	Effect.	-	-	-	6.0	-	
Actual Cost	No.	19	12	5	1	6	43
	%	100%	100%	100%	33.3%	100%	95.6%
	Effect.	5.4	5.4	6.0	6.0	4.7	
All in Rates + Actual Cost	No.	0	0	0	1	0	1
	%	0.0%	0.0%	0.0%	33.3%	0.0%	2.2%
	Effect.	-	-	-	4.0	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

4.1.3 REPORTING ACTUAL COST:

An analysis of Table 14 shows the popularity of depending on monthly cost statements. However, combining weekly and monthly cost statements seems more effective for most of the contractors.

Using weekly cost statements has the advantage of direct attention to any cost problem. However, this method is expensive to implement. In addition, sometimes not enough quantities of work are executed to report the relevant cost.

Table 14 : Frequency of Cost Statement(s).

Source(s)		Contractor Grade 5	4	3	2	1	Total
Weekly	No.	4	2	2	1	1	10
	%	21.1%	16.7%	40.0%	33.3%	16.7%	22.2%
	Effect.	4.0	3.5	6.0	7.0	6.0	
Monthly	No.	12	7	1	1	4	25
	%	63.2%	58.3%	20.0%	33.3%	66.7%	55.6%
	Effect.	5.0	5.3	6.0	5.0	5.5	
Quarterly	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	3.0	-	-	-	-	
Weekly + Monthly	No.	1	1	1	1	1	5
	%	5.3%	8.3%	20.0%	33.3%	16.7%	11.1%
	Effect.	6.0	4.0	5.0	7.0	7.0	
Monthly + Quarterly	No.	1	2	0	0	0	3
	%	5.3%	16.7%	0.0%	0.0%	0.0%	6.7%
	Effect.	4.0	4.0	-	-	-	
Weekly + Monthly + Quarterly.	No.	0	0	1	0	0	1
	%	0.0%	0.0%	20.0%	0.0%	0.0%	2.2%
	Effect.	-	-	5.0	-	-	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

The main advantages for using monthly cost statements are:

- To coincide with financial reports, specially for salary payments.
- To coincide with governmental payments.

- One month is considered a reasonable period to produce an acceptable quantity of work.

The main disadvantage experienced from using monthly reports is the neglect of labor productivity, where only the expenses incurred are recorded without any consideration of the rate of output or learning curve.

Depending on the nature and size of the projects handled, the contractors combine both periods to achieve their advantages and minimize their disadvantages. Compared with other types of reports, such as the quarterly statements, the contractors found these two periods the most economic and reliable to report projecs costs.

4.1.4 COST VARIANCE TESTING:

4.1.4.1 Cost Baseline:

In order for the contractor to conduct cost variance analysis, he should first decide on the cost baseline against which construction cost is compared. Table 15 delineates the sources from which cost baseline is derived. According to this table:

- Estimator pricing is the most commonly used source of cost baseline.

- Cost baseline for the first grade contractors is mainly derived from the estimator pricing, site feedback records and site analysis. For these contractors, depending on these three sources is most effective.

Table 15 : Sources of Data for Cost Baseline.

Source(s)		Contractor Grade 5	4	3	2	1	Total
Estimator Pricing	No.	10	4	2	1	0	12
	%	52.6%	33.3%	40.0%	33.3%	0.0%	37.8%
	Effect.	4.5	4.0	5.0	4.0	-	
Est. Pricing + Feedback Records.	No.	4	6	1	0	1	12
	%	21.0%	50.0%	20.0%	0.0%	16.7%	26.7%
	Effect.	4.5	5.0	6.0	-	5.0	
Est. Pricing + Site Analysis.	No.	5	1	2	1	1	9
	%	26.3%	8.3%	40.0%	33.3%	16.7%	20.0%
	Effect.	5.0	4.0	6.0	4.0	5.0	
Est. Pricing + Site Analysis + Feedback Records	No.	0	1	1	1	4	7
	%	0.0%	8.3%	20.0%	33.3%	66.7%	15.6%
	Effect.	-	5.0	6.0	6.0	6.5	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

- The second grade contractors are not dependent on one specific source However, combining the three sources is also most effective.
- For the third grade contractors estimator pricing and site analysis are the most popular. However, there is no clear indication which is the most effective source.

- Estimator pricing and feedback records are the most popular source for the fourth grade. As in the third grade, Table 15 gives no clear idea which is the most effective source.
- More than 50% (ten contractors out of nineteen) of the fifth grade are dependent on estimator pricing alone. On the other hand, combining this source with site analysis is most effective.

4.1.4.2 Tools of Cost Variance Testing:

An analysis of Table 16 suggests the following conclusions:

- Budgeted vs. actual cost of work done to date is the most commonly used method and forms the common denominator among most of the respondents, where it is either used alone or combined with other methods.
- Most of the methods used by the second, third, fourth and fifth grade contractors concentrate mainly on comparing the cost of work done without paying attention to the relation between the cost and schedule of work done to date.
- For the first grade contractor more systematic and comprehensive techniques are used. The most noticeable technique used is the achieved value method (Chapter 2, Page

23). Despite the expense and the time this method requires, the contractors expressed a high confidence in utilizing this technique.

- Table 16 gives no clear idea about the most effective tools for the first, third, fourth and fifth grade contractors.
- For the second grade, combining the budgeted vs. the actual cost for the work done to date and the budgeted vs. the actual unit cost is most effective. However, this high degree of effectiveness is indicated by only one third of the respondents.

Table 16 : Tools of Cost Variance Testing.

Method(s) No.		Contractor Grade 5	4	3	2	1	Total
1	No.	12	5	2	0	1	20
	%	63.2%	41.7%	40.0%	0.0%	16.7%	44.4%
	Effect.	5.1	4.2	6.0	-	4.0	
2	No.	1	1	0	0	0	2
	%	5.3%	8.3%	0.0%	0.0%	0.0%	4.4%
	Effect.	4.0	6.0	-	-	-	
3	No.	1	0	1	0	0	2
	%	5.3%	0.0%	20.0%	0.0%	0.0%	4.4%
	Effect.	4.0	-	5.0	-	-	
4	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	3.0	-	-	-	
5	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	5.0	-	-	-	-	
6	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	7.0	
1 & 2	No.	1	1	1	2	0	5
	%	5.3%	4.0%	6.0%	66.7%	0.0%	11.1%
	Effect.	3.0	4.0	6.0	5.5	-	
1 & 3	No.	2	2	0	1	0	5
	%	10.5%	16.7%	0.0%	33.3%	0.0%	11.1%
	Effect.	5.0	4.5	-	6.0	-	

A) Methods:

1) Budgeted vs. Actual Cost of Work Done to Date.
2) Budgeted vs. Forecasted Actual Total Cost at Completion.
3) Budgeted vs. Actual Unit Cost.
4) Budgeted vs. Actual Cost of Each Trade Package.
5) This Period Unit Cost vs. Cumulative Unit Cost to Last Period.
6) Achieved Value Method.

B) Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

Table 16 : Tools of Cost Variance Testing (Cont'd).

Method(s) No.		Contractor Grade 5	4	3	2	1	Total
1 & 4	No. % Effect.	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 16.7% 4.0	1 2.2%
1 & 5	No. % Effect.	0 0.0% -	1 8.3% 6.0	0 0.0% -	0 0.0% -	0 0.0% -	1 2.2%
1 & 6	No. % Effect.	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 16.7% 5.0	1 2.2%
3 & 4	No. % Effect.	1 5.3% 6.0	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 2.2%
1 & 2 & 3	No. % Effect.	0 0.0% -	1 8.3% 5.0	0 0.0% -	0 0.0% -	0 0.0% -	1 2.2%
1 & 3 & 4	No. % Effect.	0 0.0% -	0 0.0% -	1 20.0% -	0 0.0% -	0 0.0% -	1 2.2%
3 & 4 & 5	No. % Effect.	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 16.7% 7.0	1 2.2%
1 & 3 & 4 & 5	No. % Effect.	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 16.7% 7.0	1 2.2%
Total		19	12	5	3	6	45

4.1.4.3 Cost Variance Calculation:

Two methods can usually be followed to calculate variance: absolute numbers and percentages. From Table 17, it can be noticed that the contractors fluctuate between these two methods. In addition, this table gives no indication of the most effective method.

The main advantages of using percentage are:

- The amount of variance can be compared with the size of the project and expected profit or loss.
- It forms a quick reference to the amount of deviation.
- It is easy to understand by lower level people and all project personnel
- For the first grade contractors, this method is effective for comparison between the projects among their branches.

The main advantage of using absolute numbers, specially for the fifth grade contractors, is that the projects are very typical so absolute numbers form a clear indication about the size of deviation both for the upper and lower projects personnel.

Those contractors who use both absolute numbers and percentage (specially the first grade contractors) benefit from the full comparison with the project size. How-

ever, the main disadvantage for this practice is the more paper work involved.

Table 17 : Cost Variance Calculation.

Method(s)		Contractor Grade 5	4	3	2	1	Total
Absolute Numbers	No.	10	3	2	1	0	16
	%	52.6%	25.0%	40.0%	33.3%	0.0%	35.6%
	Effect.	4.8	5.7	5.0	4.0	-	
Percentage	No.	7	8	2	1	3	21
	%	36.8%	66.7%	40.0%	33.3%	50.0%	46.7%
	Effect.	5.4	5.0	6.0	6.0	5.0	
Absolute + Percentage	No.	2	1	1	1	3	8
	%	10.5%	8.3%	20.0%	33.3%	50.0%	17.8%
	Effect.	4.5	4.8	6.0	6.0	5.3	
Total		19	12	5	3	6	45

Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

4.1.5 CAUSES OF HIGH COSTS AND CORRECTIVE ACTIONS:

During construction, whenever any deviation in cost is spotted, the first reaction is to determine the cause of this discrepancy.

Table 18 summarizes the techniques followed by the contractors to investigate any cost discrepancy. For most of the contractors, inference and logic, informal investigation and periodical supervisory meetings form the common denominator for all the methods used.The other methods are: intuition, spot costing and work study.

A very important point that should be highlighted is that the bigger the size of the project is, the more formal and systematic are the methods used to investigate the cost discrepancy (e.g. spot costing and work study). (For more information on these techniques refer to Chapter 2, Page 25).

Table 18 : Investigating Cost Discrepancy.

Method#		Contractor Grade 5	4	3	2	1	Total
1	No.	8	2	0	0	0	10
	%	42.1%	16.7%	0.0%	0.0%	0.0%	22.2%
	Effect.	5.3	4.5	-	-	-	
2	No.	2	1	0	0	0	3
	%	10.5%	8.3%	0.0%	0.0%	0.0%	6.7%
	Effect.	4.0	5.0	-	-	-	
4	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	6.0	-	-	-	
5	No.	0	1	2	1	0	4
	%	0.0%	8.3%	40.0%	33.3%	0.0%	8.9%
	Effect.	-	5.0	5.0	5.0	-	
6	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	5.0	
1 & 2	No.	2	2	1	0	0	5
	%	10.5%	16.7%	20.0%	0.0%	0.0%	11.1%
	Effect.	5.5	4.0	4.0	-	-	

A) Methods:
1) Informal Investigation
2) Inference/Logic
3) Intuition/Gut Feeling
4) Work Study
5) Periodical Supervisory Meetings
6) Spot Costing

B) Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

Table 18 : Investigating Cost Discrepancy (Cont'd).

Method#		Contractor Grade 5	4	3	2	1	Total
1 & 3	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	4.0	-	-	-	-	
1 & 4	No.	0	0	0	1	2	3
	%	0.0%	0.0%	0.0%	33.3%	33.3%	6.7%
	Effect.	-	-	-	3.0	3.5	
1 & 5	No.	4	4	2	0	2	12
	%	21.1%	33.3%	40.0%	0.0%	33.3%	26.7%
	Effect.	5.8	4.2	5.5	-	5.0	
2 & 5	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
	Effect.	3.5	-	-	-	-	
1 & 4 & 5	No.	0	0	0	1	0	1
	%	0.0%	0.0%	0.0%	33.3%	0.0%	2.2%
	Effect.	-	-	-	6.0	-	
2 & 3 & 5	No.	0	1	0	0	0	1
	%	0.0%	8.3%	0.0%	0.0%	0.0%	2.2%
	Effect.	-	6.0	-	-	-	
1 & 2 & 3 & 5	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	7.0	
Total		19	12	5	3	6	45

The contractors who use informal investigation, inference and intuition justified their effectiveness by the simplicity in nature which do not require thorough studies, specially in small and typical projects. However, these contractors admitted the lack of accuracy in depending only on these methods, especially whenever the size of the project expands. In addition, by the use of these "tried and true" methods, a long time may pass before the true cause of cost discrepancy is discovered.

The contractors who use the more advanced techniques, such as work study, are one of the following:

* For the contractors of lower grade numbers (first and second), these methods are used to cope with the size and duration of their projects. This productivity-oriented technique helps in investigating any cost discrepancy in the long run and forms a systematic evaluation technique (average job time may exceed five years) (Appendix B, Table 37).
* The contractors of higher grade numbers (fourth grade) who use this method are mainly specialized steel builders. By using the work study, these builders form an evaluation technique for all the projects they are involved in.

After determining the cause(s) of the cost deviation, the next step is to take the necessary corrective action(s). Analysis of Table 19 reveals a high dependance on incentive schemes as corrective actions. These incentives range from the very simple forms of bonuses and an increase in the overtime for the fifth grade contractors, to the more formal ways of promotion and raise in salary for the first grade contractors. Most of the interviewees expressed their confidence in using incentives to correct any deviation by increasing the productivity of the workers.

The major drawbacks experienced from using this method are as follows:

1) This method is expensive to apply specially when the technique used depends on increasing workers' overtime.
2) Many employees have got used to this method, so their productivity during normal working hours is decreased to maximize their overtime.

In addition to incentive schemes, other methods are used. For the higher grade number contractors - specially the fifth - it is noticed that they depend on methods that speed up the process to complete the project as soon as possible or to transfer responsibility to a subcontractor. These methods are noticed to be used when the deviation is high.

Table 19 : Corrective Actions.

Method#		Contractor Grade 5	4	3	2	1	Total
1	No. % Effect.	8 41.1% 5.5	7 58.3% 5.0	1 20.0% 4.0	0 0.0% -	0 0.0% -	16 35.6%
2	No. % Effect.	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0%
3	No. % Effect.	0 0.0% -	0 0.0% -	1 20.0% 6.0	0 0.0% -	2 33.3% 5.0	3 6.7%
4	No. % Effect.	0 0.0% -	2 16.7% 5.0	0 0.0% -	0 0.0% -	0 0.0% -	2 4.4%
5	No. % Effect.	2 10.5% 4.0	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	2 4.4%
6	No. % Effect.	1 5.3% 5.5	0 0.0% -	0 0.0% -	0 0.0% -	0 0.0% -	1 2.2%
1 & 2	No. % Effect.	0 0.0% -	1 8.3% 5.5	0 0.0% -	0 0.0% -	0 0.0% -	1 2.2%
1 & 3	No. % Effect.	2 10.5% 4.5	1 8.3% 4.0	0 0.0% -	0 0.0% -	0 0.0% -	3 6.7%

A) Methods:
1) Incentive Scheme.
2) Work Study Technique.
3) Spot costing.
4) Job Cards.
5) Reorganizing Work Force.
6) Assigning Specialist for Supervision.
7) Overtime (rush process).
8) Increase Work Load.
9) Subcontract the Work.

B) Effect. : Degree of effectiveness (average response on a scale from 1(min.) to 7(max.).

Table 19 : Corrective Actions (Cont'd).

Method#		Contractor Grade 5	4	3	2	1	Total
1 & 4	No.	0	0	2	1	1	4
	%	0.0%	0.0%	40.0%	33.3%	16.7%	8.9%
	Effect.	-	-	6.5	5.0	4.0	
1 & 7	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	5.0	-	-	-	-	
1 & 8	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	5.0	-	-	-	-	
1 & 9	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
	Effect.	5.5	-	-	-	-	
2 & 3	No.	0	0	0	1	0	1
	%	0.0%	0.0%	0.0%	33.3%	0.0%	2.2%
	Effect.	-	-	-	6.0	-	
3 & 4	No.	1	1	1	1	1	5
	%	5.3%	8.3%	20.0%	33.3%	16.7%	11.1%
	Effect.	5.0	4.0	6.0	5.0	4.0	
1 & 5 & 9	No.	1	0	0	0	0	1
	%	5.3%	0.0%	0.0%	0.0%	0.0%	2.2%
	Effect.	5.0	-	-	-	-	
1 & 2 & 3 & 4	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	5.0	
1 & 2 & 3 & 5	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
	Effect.	-	-	-	-	4.0	
Total		19	12	5	3	6	45

For the contractors of lower grade numbers -especially the first- more formal and systematic ways are used, such as work study, spot costing and job cards (Chapter 2, Page 25). These contractors combine these different methods to allow maximum benefit. However, these contractors are concerned about the cost and paper-work involved.

A very important point which can be noticed here is that some methods, such as work study, are not actually corrective actions. However, the respondents declared that investigating the causes of cost variance and corrective actions form a continuous cycle of variance evaluation. For example, by the work study -which is a productivity evaluation technique- the course of deviation caused by the project personnel or the process can be detected, corrected and tested.

By analyzing the degree of effectiveness, Table 19 does not aid in detecting the most effective techniques. The close degree of effectiveness of the methods used by each grade indicates the contractors are not fully confident of a particular technique(s). For the fourth and fifth grade contractors, this is due to the lack of knowledge of other techniques, while for the rest of the contractors it is due to their dependence on different techniques that suit each particular project.

4.2 FACTORS AFFECTING THE LEVEL OF CONTROL:

Determining the level of control that should be exerted to control construction cost is a critical decision that should be made before the construction starts. In deciding on the level of control, all the factors that may affect the project cost should be gathered and evaluated. Such evaluation will aid project personnel in deciding which factors contribute most to budget overrun and in turn place tighter control on them.

In this research, the level of control was represented by three parameters: degree of work breakdown structure, degree of organization breakdown structure and frequency of reporting.

From an extensive review of the literature, thirty-one factors were found to have an effect on the level of control exerted during construction (36,37). These factors were grouped into five categories: Company Characteristics, Project Characteristics, Project Documents, Labor, Equipment and Outside Influences.

To analyze the findings of the research, the factors were ranked according to their importance in affecting each of the three parameters of the level of control. The importance

index for each factor was calculated by the following formula: (40)

$$\text{Importance Index} = \sum_{i=1}^{7} [a_i * X_i] * 100 / 7 \qquad \{10\}$$

Where:-

a_i = Constant Expressing the weight given to each response

$X_i = \frac{N_i}{N}$

N_i = The Frequency of the response

N = Total Number of Responses

4.2.1 Factors Affecting the Work Breakdown Structure (W.B.S.):

One of the most important aspects in an effective level of control is an appropriate decision on how detailed the work should be divided into its constituent activities for planning, scheduling and controlling purposes.

Table 20 summarizes the importance index each of the thirty one factors has on the Work Breakdown Structure, in general as well as according to the contractors five grades. These factors are ranked according to their importance indices.

From Figure 18, Company Characteristics is the most influential broad category on the degree of W.B.S. for all the grades in general. On the other hand, tight project

schedule is noticed to rank first among the thirty one factors (Table 20).

When looking at each grade in particular, Company Characteristics is seen to be the most important category for the first, second and fourth grades. On the other hand, Project Documents is the most important for the third and fifth (Figs. 19-23).

Among the thirty-one factors, Use of Computers is the most important for the first and second grade contractors, Project Size for the third grade, Tight Project Schedule for the fourth grade and Contract Clauses for the fifth (Table 20).

FACTORS	All Grades		Grade # 5		Grade # 4		Grade # 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
A. PROJECT CHARACTERISTICS		64.92		48.14		72.82		70.95		65.08		65.48
- Tight project schedule	1	74.60	4	63.16	1	86.90	2	85.71	6	80.95	16	73.81
- Size of project	3	70.79	20	53.38	2	82.14	1	88.57	7	76.19	4	85.71
- Complexity of design	5	70.16	3	63.91	15	64.05	8	77.14	5	80.95	9	80.95
- Quality Required	21	60.95	7	60.15	31	54.76	12	68.57	16	61.90	19	69.05
- Type of project	22	59.68	21	53.38	5	76.19	24	57.14	15	61.90	29	47.62
- Project location	29	53.33	16	54.89	17	67.86	30	48.57	30	28.57	31	35.71
B. PROJECT DOCUMENTS		64.55		62.66		64.68		82.85		46.03		64.28
- Completeness of plans and spec's.	12	65.08	5	63.16	22	69.29	4	85.71	25	47.62	22	64.28
- Contract clauses	14	65.08	1	66.16	13	70.24	3	85.71	29	33.33	28	50.00
- Clarity of project	17	63.49	9	58.65	29	59.52	9	77.14	19	57.14	13	78.57
C. LABOR		61.43		54.32		66.67		57.14		69.05		73.21
- Skill of labor reqired/ available	6	67.30	8	59.64	10	72.62	23	60.00	8	76.19	6	83.33
- Poor labor productivity	15	63.81	13	55.64	20	64.29	19	62.86	3	85.71	10	78.57
- Number of labor required/ available	18	63.17	15	55.64	18	66.67	22	60.00	9	71.43	11	78.57
- Labor relations problems	31	51.43	30	46.62	23	63.10	31	45.71	26	42.86	27	52.38
D. EQUIPMENT		58.10		54.88		62.50		68.57		42.86		58.33
- Type of equipment required/available	24	58.41	12	56.39	25	61.90	14	68.57	28	42.86	26	57.14
- Number of equipment required/available	25	57.78	22	53.38	24	63.10	13	68.57	27	42.86	25	59.52

Table 20 : Factors Importance Index for W.B.S.

FACTORS	All Grades		Grade 5		Grade # 4		Grade # 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
E. COMPANY CHARACTERISTICS		66.66		56.39		73.33		69.71		70.95		81.19
- Timing of resources procurement	2	73.01	2	65.41	4	77.38	17	65.17	2	90.48	5	85.71
- Number of supervisors required/available	4	70.48	11	58.65	6	76.19	7	82.86	4	85.71	12	78.57
- Size of company	7	66.98	6	60.90	7	75.00	25	57.14	11	71.43	14	76.19
- Use of technology (computers)	8	66.35	24	52.63	19	65.48	16	65.71	1	95.24	1	97.62
- Reliability of budget estimate	9	66.35	10	58.65	12	71.43	18	65.71	17	61.90	7	83.33
- Poor technical and administrative performance	10	65.17	26	50.38	8	73.81	10	74.28	13	66.67	2	90.48
- Continuous change orders	11	65.71	19	54.14	16	69.05	5	85.71	18	61.90	8	80.95
- Unfamiliarity with some construction process	13	65.08	18	54.14	11	71.43	6	82.86	12	66.67	17	71.43
- Work load (no. of projects available.)	16	63.81	14	55.64	3	79.76	20	62.86	20	57.14	23	61.90
- Type of approach to project management	19	63.17	23	53.38	9	73.81	28	54.28	22	52.38	3	85.71
F. OUTSIDE INFLUENCES		56.88		50.01		61.71		61.90		54.76		65.87
- Owner interference during construction	20	61.27	17	54.89	14	70.24	27	57.14	21	57.14	20	69.05
- Unforeseen site conditions	23	59.36	25	52.63	26	60.71	29	54.28	10	71.43	15	76.19
- Continuous change in governmental rules and regulations.	26	57.78	29	48.87	21	64.29	26	57.14	14	66.67	21	69.05
- Weather	27	54.92	27	50.38	28	59.52	11	71.43	23	52.38	30	47.62
- Inflation	28	54.60	28	49.68	27	59.52	15	68.57	31	28.57	24	61.90
- Claims	30	53.33	31	43.61	30	55.95	21	62.86	24	52.38	18	71.43

Table 20 : Factors Importance Index for W.B.S. (cont'd.)

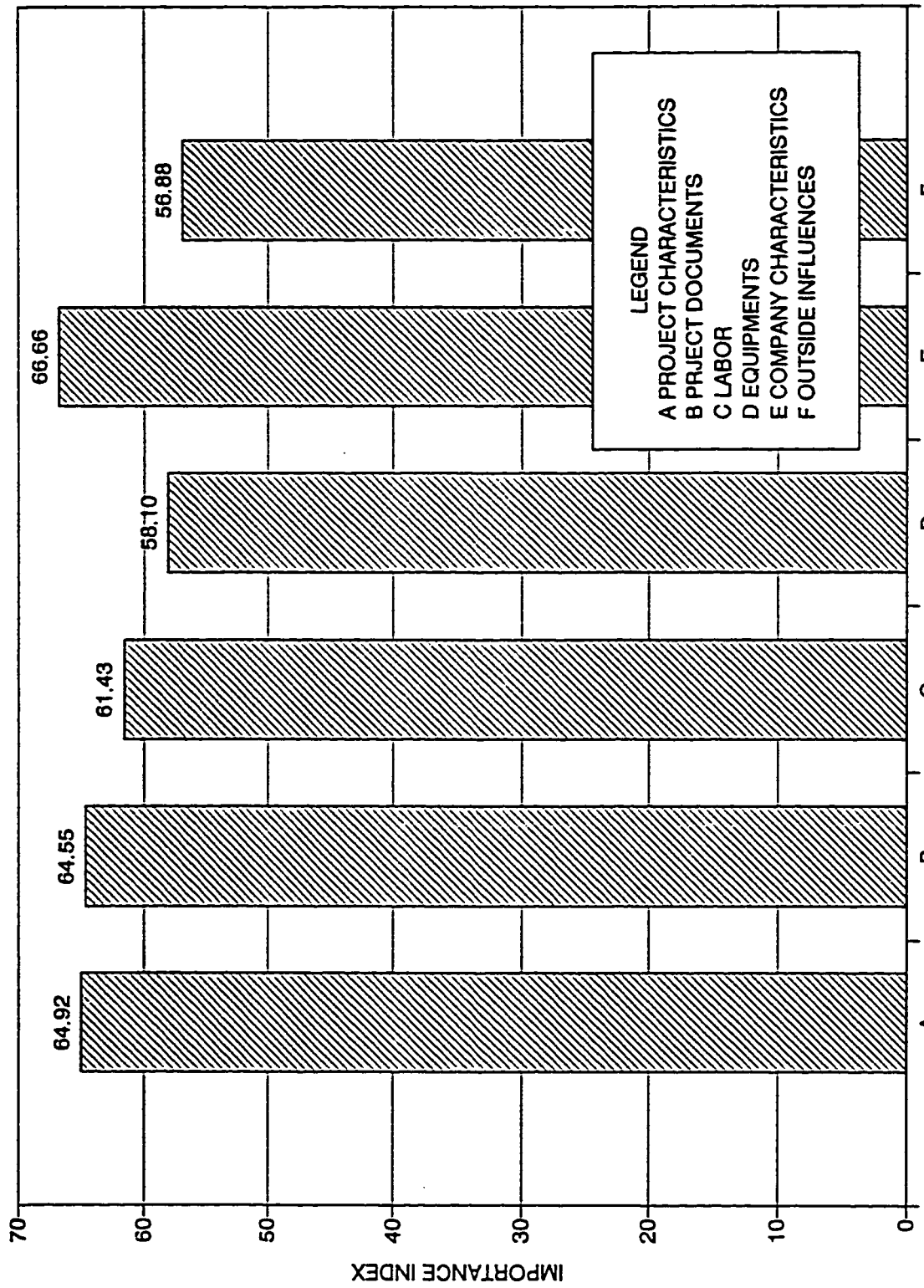


Fig. 18 : W.B.S. Importance Index for all Grades (Broad Categories).

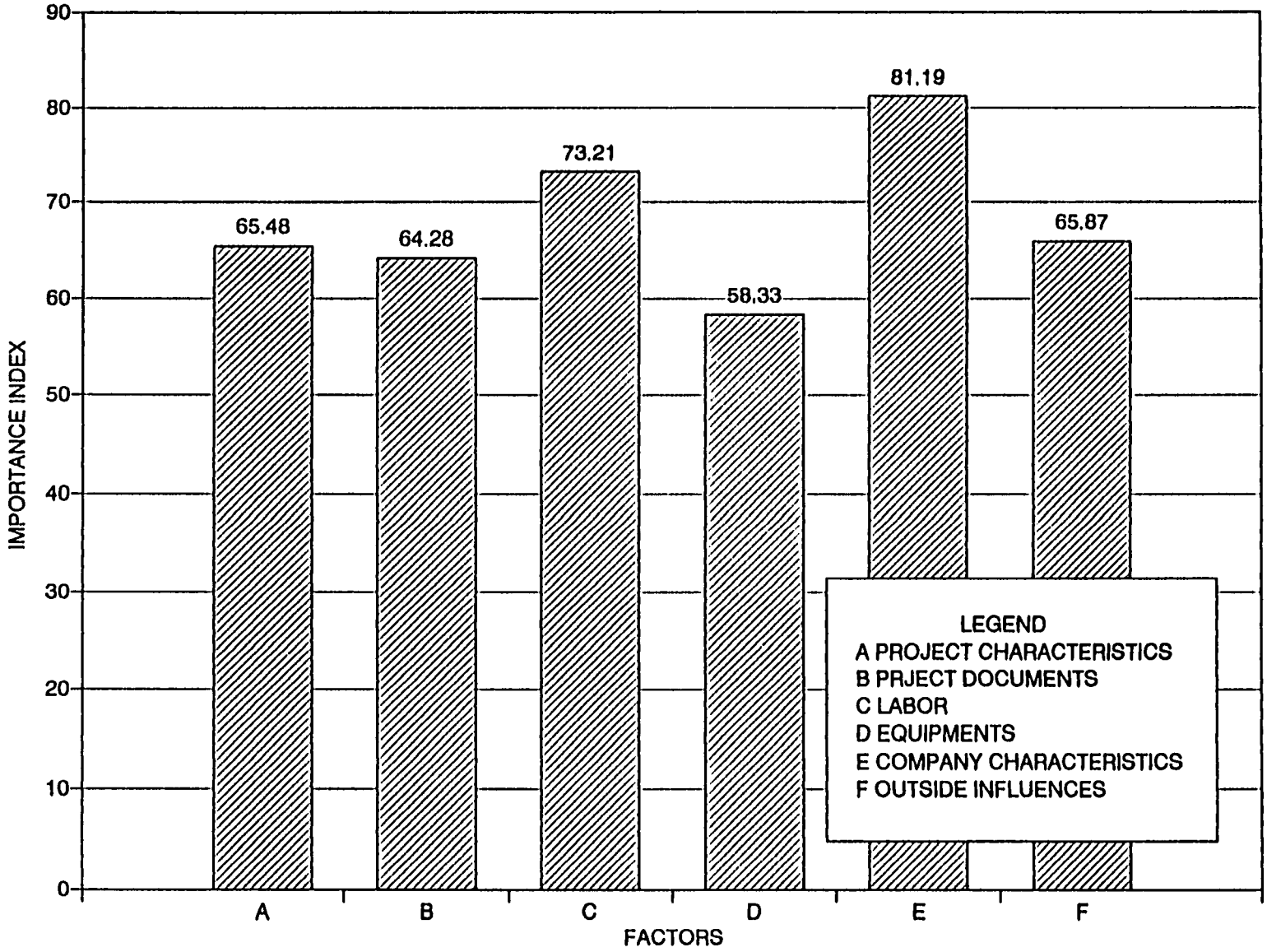


Fig. 19 : W.B.S. Importance Index for Grade#1 (Broad Categories).

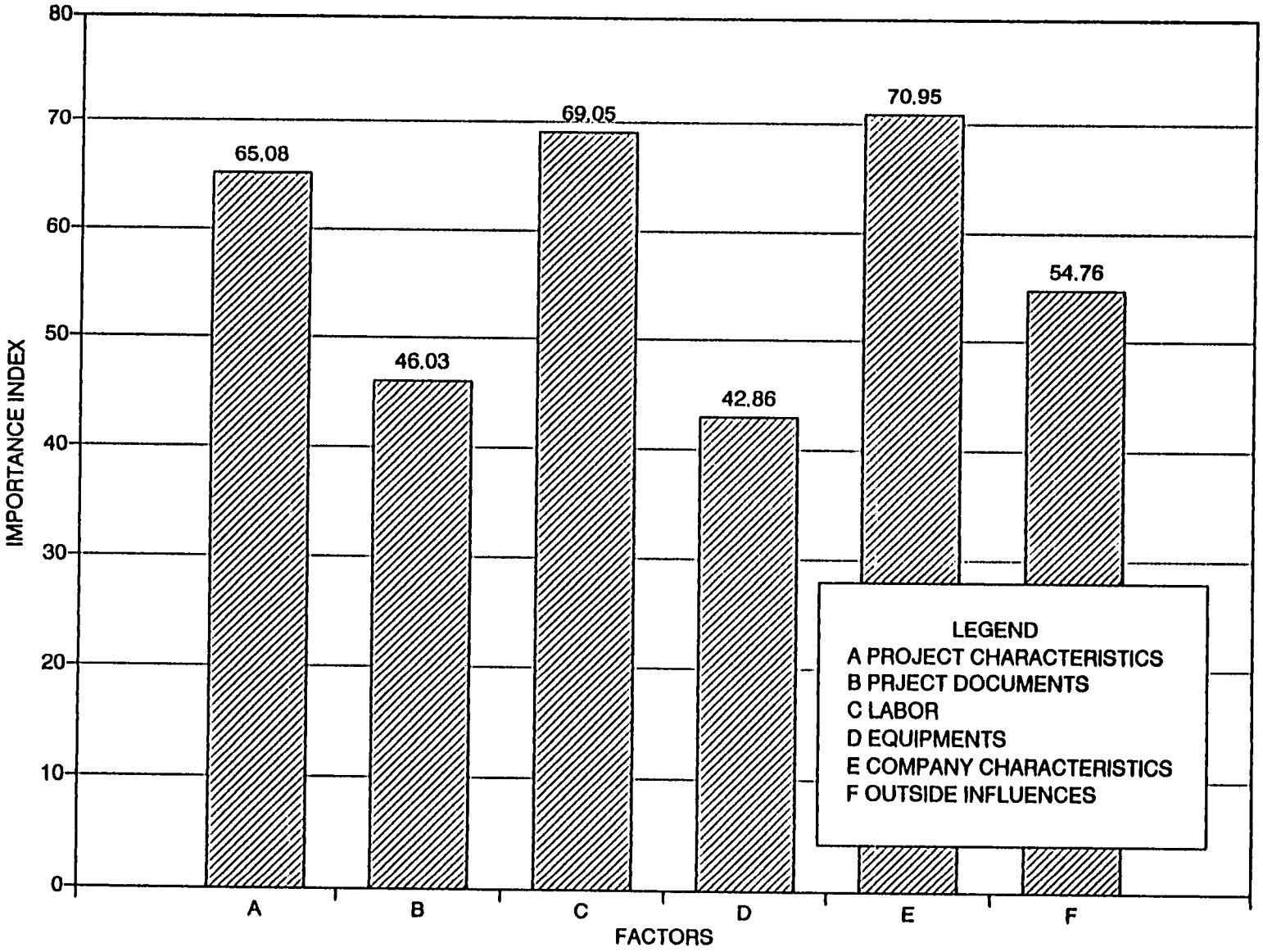


Fig. 20 : W.B.S. Importance Index for Gade#2 (Broad Categories).

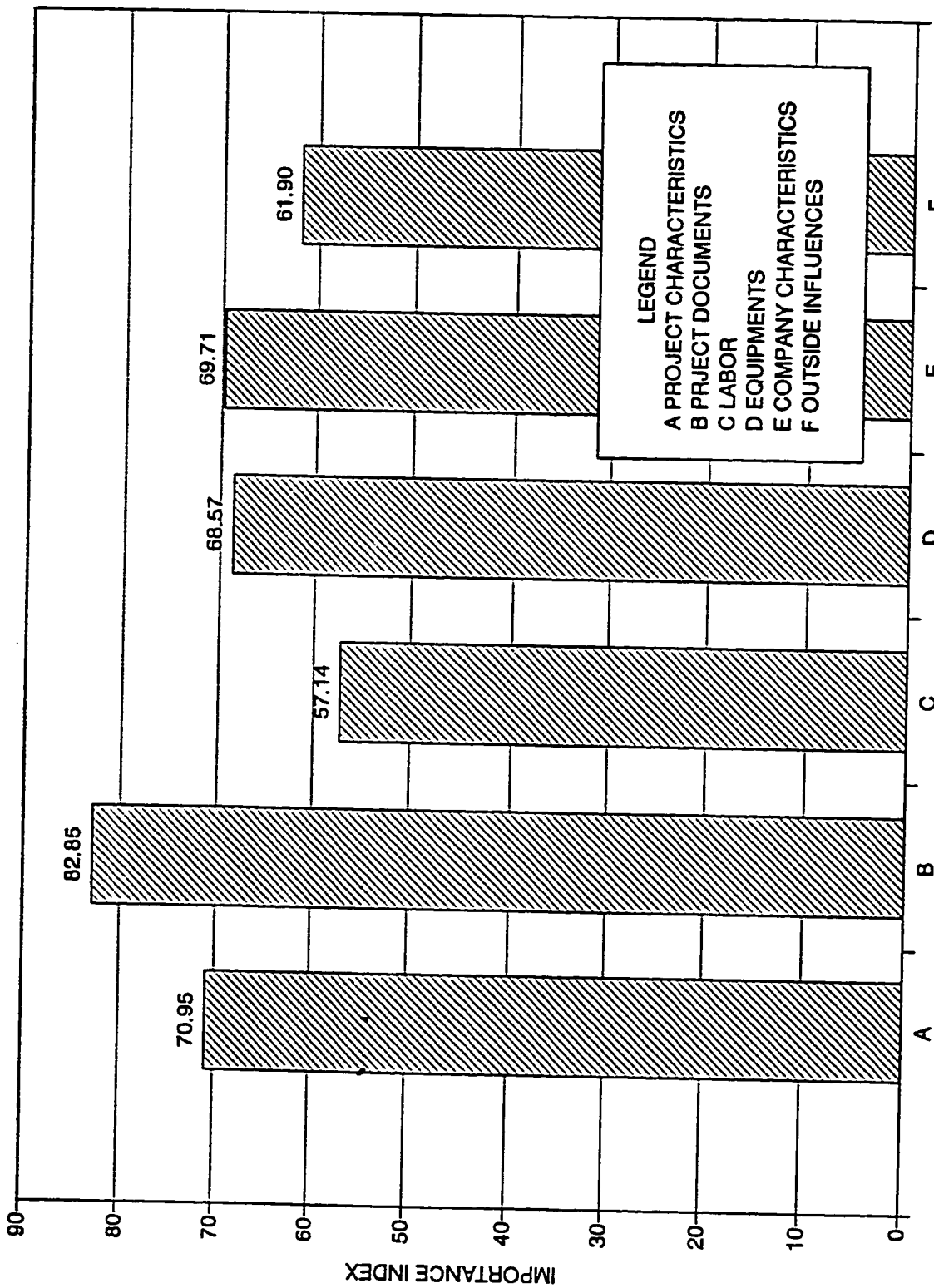


Fig. 21 : W.B.S. Importance Index for Grade#3 (Broad Categories).

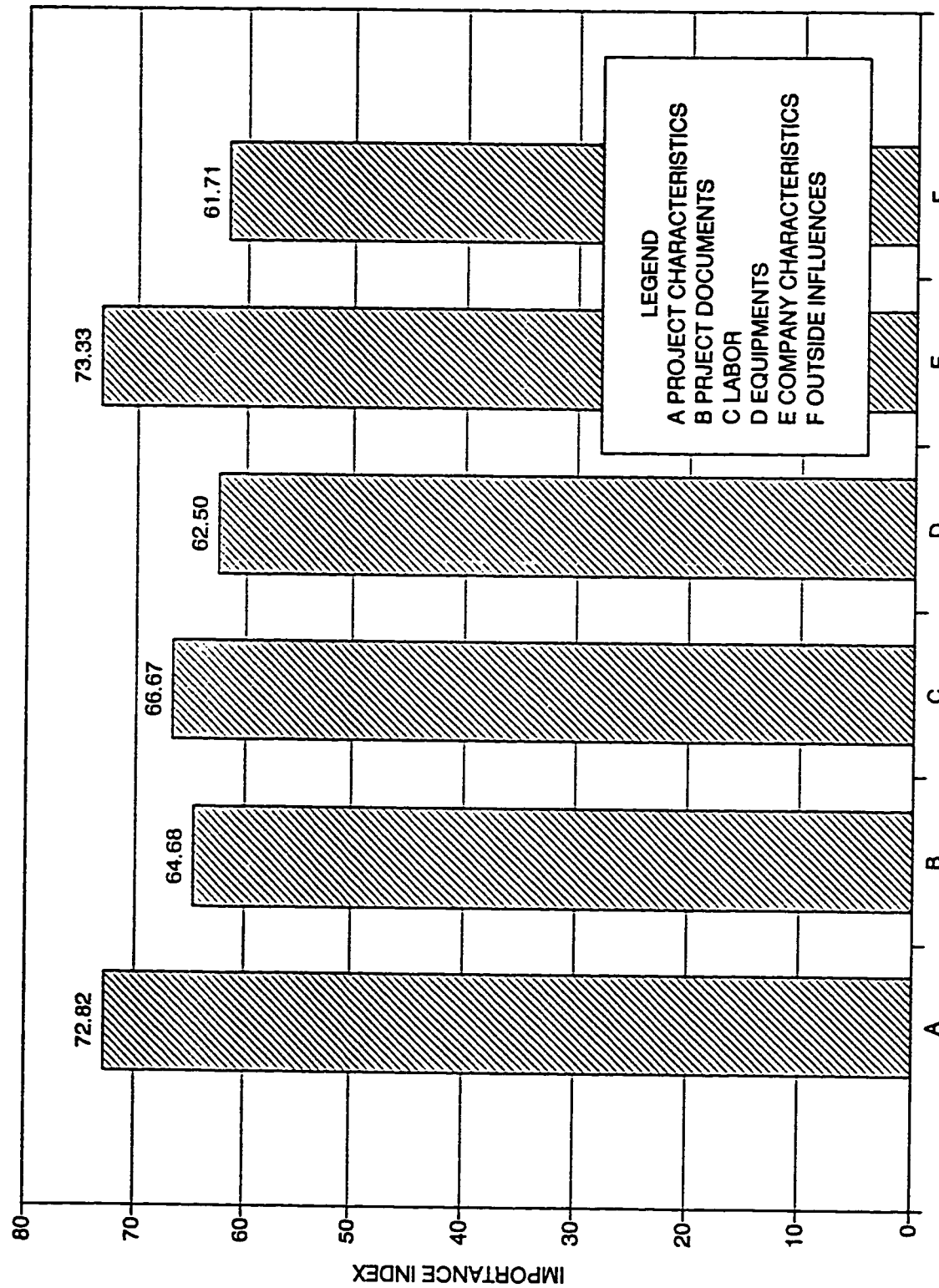


Fig. 22 : W.B.S. Importance Index for grade#4 (Broad Categories).

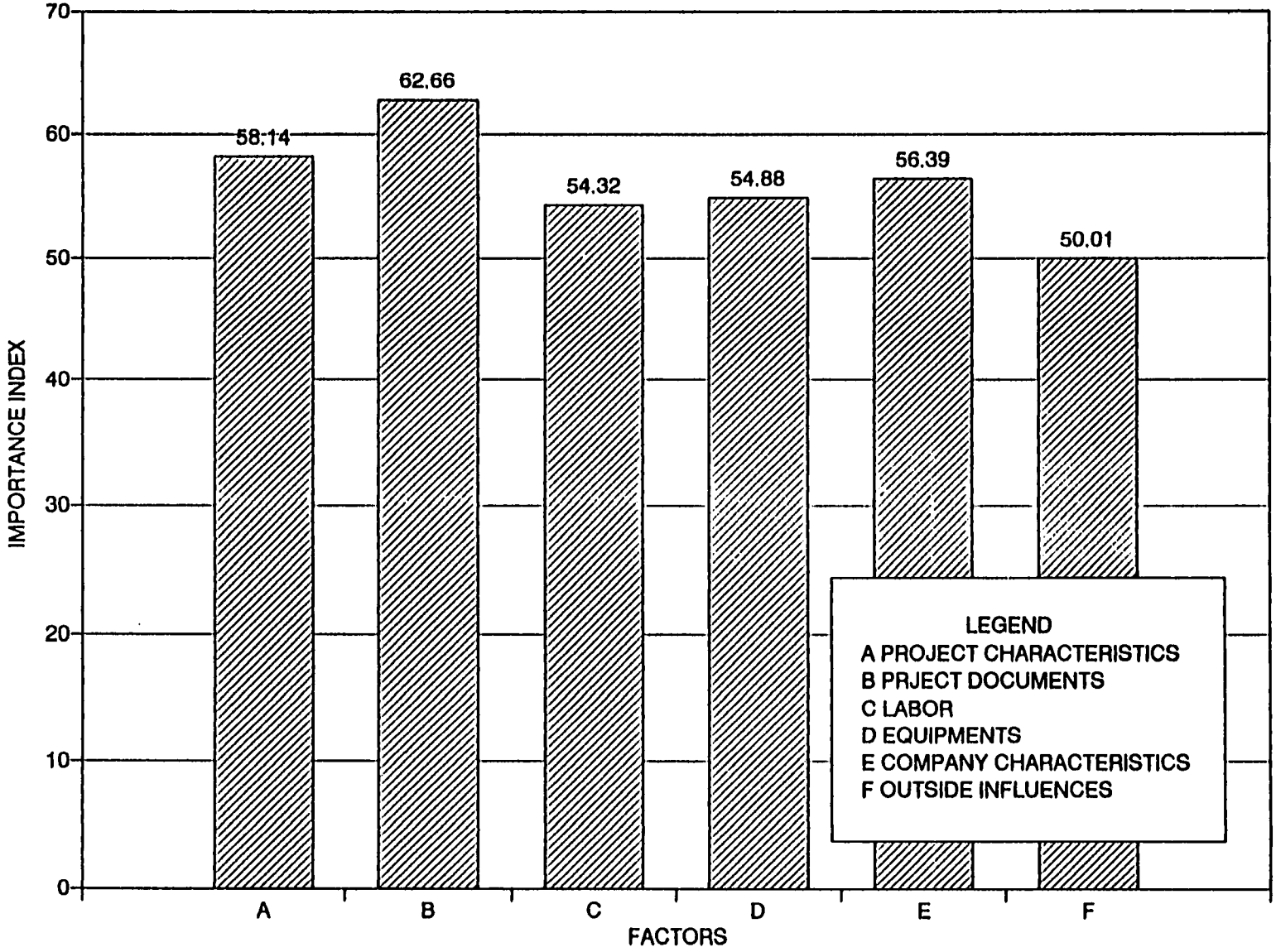


Fig. 23 : W.B.S. Importance Index for Grade#5 (Broad Categories).

In order to identify the factors that are viewed differently by the five contractors grades (that discriminate the five grades) DISCRIMINANT ANALYSIS was conducted (for more information regarding discriminant analysis refer to Appendix C)(41).

Table 21 summarizes the results of the Discriminant Analysis. From these results the following can be observed:-

1) Canonical correlation for function 1 = 0.930
2) Canonical correlation for function 2 = 0.899
3) Canonical correlation for function 3 = 0.793
4) Canonical correlation for function 4 = 0.735

According to the above, the degree of association between the five grades and (CAN1, CAN2, CAN3 and CAN4) is very high. These results show the use of contractors' grades is a good discriminator (41).

By examining the Eigen values:

* Eigen Value for Function 1 = 6.387
* Eigen Value for Function 2 = 4.221
* Eigen Value for Function 3 = 1.688
* Eigen Value for Function 4 = 1.176

CANONICAL DISCRIMINANT ANALYSIS

45 OBSERVATIONS	44 DF TOTAL	
31 VARIABLES	40 DF WITHIN CLASSES	
5 CLASSES	4 DF BETWEEN CLASSES	

	CANONICAL CORRELATION	ADJUSTED CANONICAL CORRELATION	APPROX STANDARD ERROR	SQUARED CANONICAL CORRELATION	EIGENVALUE	EIGENVALUES OF INV(E)*H = CANRSQ/(1-CANRSQ) DIFFERENCE	PROPORTION
1	0.929851	0.868300	0.020409	0.864622	6.3867	2.1659	0.4741
2	0.899144	0.830397	0.028876	0.808461	4.2209	2.5328	0.3133
3	0.792454	0.627514	0.056084	0.627983	1.6880	0.5117	0.1253
4	0.735197	0.588629	0.069270	0.540515	1.1763	.	0.0873

TESTS OF H0: THE CANONICAL CORRELATION IN THE CURRENT ROW AND ALL THAT FOLLOW ARE ZERO

	LIKELIHOOD RATIO	APPROX F	NUM DF	DEN DF	PR > F
1	0.00443242	0.9937	124	42.3964	0.5264
2	0.03274109	0.8019	90	33.808	0.7957
3	0.17093654	0.5870	58	24	0.9494
4	0.45948532	0.5462	28	13	0.9123

MULTIVARIATE TEST STATISTICS AND F APPROXIMATIONS
S=4 M=13 N=4

STATISTIC	VALUE	F	NUM DF	DEN DF	PR > F
WILKS' LAMBDA	0.004432422	0.994	124	42.3964	0.5264
PILLAI'S TRACE	2.84158	1.029	124	52	0.4648
HOTELLING-LAWLEY TRACE	13.47198	0.923	124	34	0.6346
ROY'S GREATEST ROOT	6.386727	2.678	31	13	0.0313

NOTE: F STATISTIC FOR ROY'S GREATEST ROOT IS AN UPPER BOUND

Table 21 : Canonical Discriminant analysis for W.B.S.

From the above values, functions 1 and 2 - which have the highest values - seem to be the most powerful discriminators, where function one contributes 47.4% of the discriminating power, and function two contributes 31.3% (Table 21)(41).

5) Square Canonical correlation for function 1 = 0.865
6) Square Canonical correlation for function 2 = 0.808
7) Square Canonical correlation for function 3 = 0.628
8) Square Canonical correlation for function 4 = 0.541

From this, it can be verified that the proportion of variation in the discriminant functions is explained by the groups, specially for functions 1 and 2 (41).

In Table 21, Wilk's Lambda = 0.004. This suggests a high degree of discrimination between the groups, which is not due to sampling (41).

Figure 24 shows a plot for CAN1 and CAN2. From this plot a noticeable discrimination is observed. This discrimination can be visualized by allocating the centroid for each group.

To study the factors which contribute most to the discrimination, the two previously explained methods can be used, as follows: (41)

1) TOTAL CANONICAL STRUCTURE:

Table 22 shows the total canonical structure for CAN1 and CAN2. For CAN1 "Size of Project" is the only discriminating factor. On the other hand, nine discriminating factors are within CAN2. These factors are: Size of Project, Contract Clauses, Poor Labor Productivity, Skill of Labor Required/Available, Use of Computers, Timing of Resources Procurement, Poor Technical and Administrative Performance, Number of Supervisors Required/Available and Unforeseen Site Conditions.

According to the above factors, the broad categories contribute to the discrimination as follows:

- 11.1% (1/9) of the discrimination is related to the Project Characteristics.
- 11.1% (1/9) of the discrimination is related to Project Documents.
- 22.2% (2/9) of the discrimination is related to Labor.
- 0.0% of the discrimination is related to Equipment.
- 44.4% (4/9) of the discrimination is related to Company Characteristics.

- 11.1% (1/9) of the discrimination is related to Outside Influences.

From the above, it can be concluded that most of the discrimination is related to Company Characteristics.

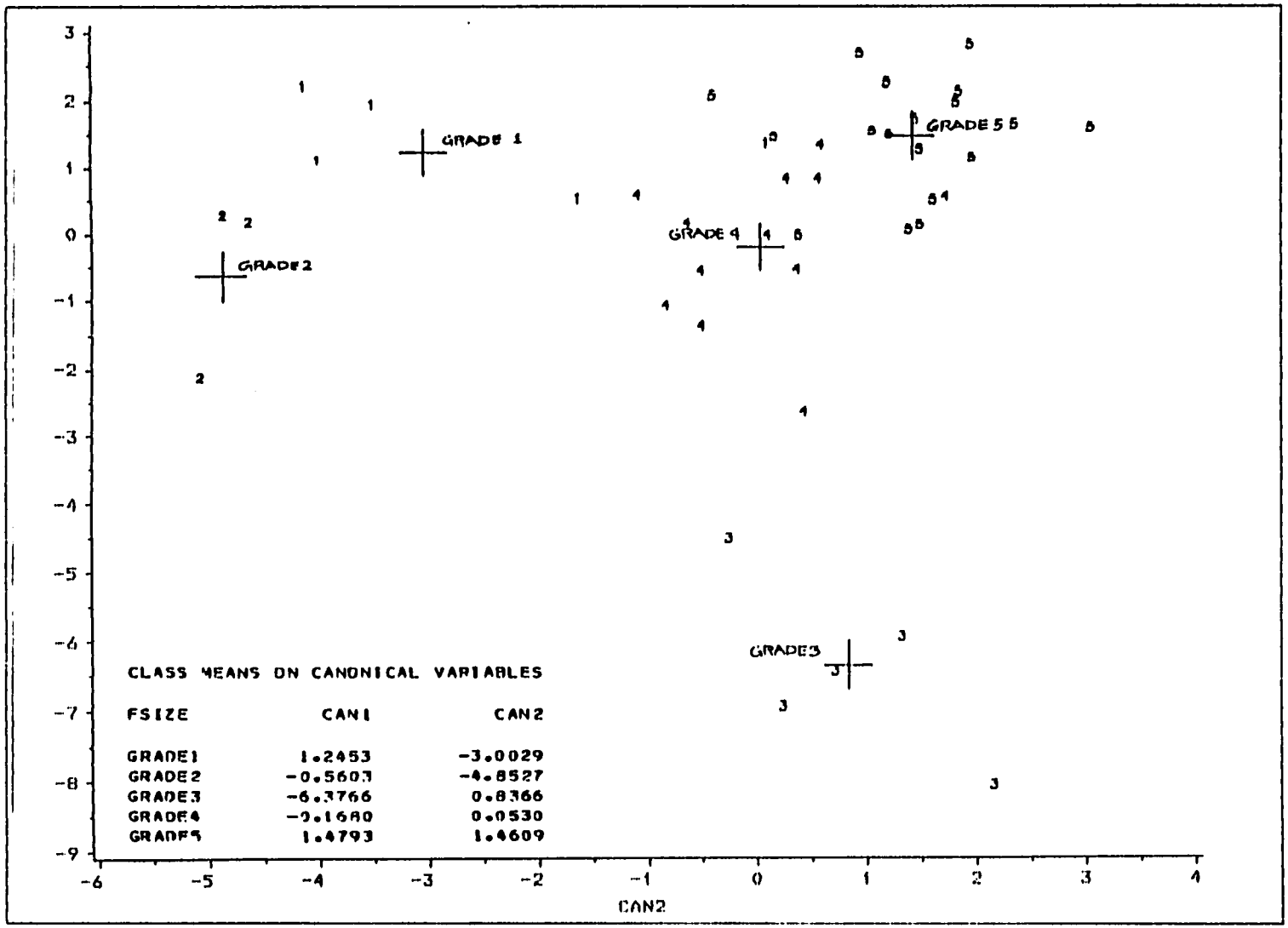


Figure 24 : Plot of (CAN1 & CAN2) for W.B.S.

CANONICAL DISCRIMINANT ANALYSIS

TOTAL CANONICAL STRUCTURE

	CAN1	CAN2	CAN3	CAN4
WBS1	-0.3571	-0.3484	-0.3803	0.0980
WBS2	-0.0725	0.0041	-0.3138	-0.3000
WBS3	-0.2578	-0.1561	-0.3005	-0.1367
WBS4	-0.1185	-0.2245	-0.0043	0.0888
WBS5	-0.0648	-0.0555	0.1029	0.1655
WBS6	0.0232	0.2754	-0.2949	-0.1653
WBS7	-0.2413	0.3759	-0.1551	0.0585
WBS8	-0.2686	0.1497	-0.0486	0.2088
WBS9	-0.1664	-0.1247	-0.0146	0.3325
WBS10	-0.0391	-0.3199	-0.0235	0.0150
WBS11	-0.0057	-0.2722	-0.1446	0.0843
WBS12	0.0394	-0.3176	-0.2046	0.0624
WBS13	0.0178	-0.0166	-0.2814	-0.0488
WBS14	-0.1555	0.0505	-0.1981	0.1120
WBS15	-0.1263	0.1030	-0.1315	0.0914
WBS16	0.0676	-0.1991	-0.2384	-0.0272
WBS17	-0.2744	-0.1503	-0.1883	0.0592
WBS18	-0.0542	-0.5287	-0.0554	0.1571
WBS19	0.0320	-0.3877	-0.1471	-0.0403
WBS20	-0.1751	-0.3503	-0.3208	0.2278
WBS21	-0.0295	-0.2368	-0.2754	0.2187
WBS22	-0.2648	-0.3065	-0.1619	-0.0243
WBS23	-0.0760	-0.0368	-0.3792	-0.1186
WBS24	0.0567	-0.2295	-0.3924	0.2060
WBS25	-0.2838	-0.1932	-0.1855	0.2331
WBS26	-0.0550	-0.2325	-0.1794	0.0099
WBS27	-0.1515	0.0662	-0.2210	0.2353
WBS28	-0.2520	0.0514	-0.0949	-0.0607
WBS29	0.0266	-0.3082	-0.0881	0.0904
WBS30	-0.1387	-0.2141	-0.1568	0.2060
WBS31	-0.0003	-0.1141	-0.2653	0.0248

• Project Characteristics.
WBS 1 = Size of project
WBS 2 = Type of project
WBS 3 = Tight project schedule
WBS 4 = Complexity of Design
WBS 5 = Quality Required
WBS 6 = Project Location.

• Project Documents.
WBS 7 = Contract clauses
WBS 8 = Completeness of plans and specs.
WBS 9 = Clarity of project objectives.

• Labor.
WBS 10 = Poor labor productivity
WBS 11 = Number of labor required/available
WBS 12 = Skill of labor required/available
WBS 13 = Labor relations problems.

• Equipment.
WBS 14 = Number of equipment required/available
WBS 15 = Type of equipment required/available

• Company Characteristics.
WBS 16 = Size of company
WBS 17 = Unfamiliarity with some construction process
WBS 18 = Use of Technology (computers)
WBS 19 = Timing of Resources Procurement
WBS 20 = Poor technical and administrative performance
WBS 21 = Reliability of budget estimate
WBS 22 = Number of supervisors required/available
WBS 23 = Work load (No. of projects available)
WBS 24 = Type of approach to project management
WBS 25 = Continuous change orders.

• Outside Influences.
WBS 26 = Continuous change in government rules and regulations
WBS 27 = Inflation
WBS 28 = Weather
WBS 29 = Unforeseen site conditions
WBS 30 = Claims
WBS 31 = Owner interference during construction

Table 22 : Total Canonical Structure for W.B.S.

2) STANDARD CANONICAL COEFFICIENTS:

Table 23 lists the standardized canonical coefficients for the first and second functions (CAN1 & CAN2). The most discriminating factors for CAN1, are nine: Tight Project Schedule, Project Location, Contract Clauses, Completeness of Plans and Specifications, Number of Equipment Required/Available, Size of company, Number of Projects Available, Type of Approach to Project Management, and Unforeseen Site Conditions. Among the above factors, Project Location and Size of Company are the greatest discriminators because they have standard deviations greater than four.

The second canonical function is significantly related to only one factor, which is Tight Project Schedule.

The effect of the broad categories in terms of discrimination can be summarized as follows:

- 22.2% (2/9) of the discriminating factors are related to Project Characteristics.
- 22.2% (2/9) of the discriminating factors are related to Project Documents.
- 0% of the discriminating factors are related to Labor.
- 11.1% (1/9) of the discriminating factors are related to

Equipment.

- 33.3% (3/9) of the discriminating factors are related to Company Characteristics.

- 11.1% (1/9) of the discriminating factors are related to Outside Influences.

CANONICAL DISCRIMINANT ANALYSIS

STANDARDIZED CANONICAL COEFFICIENTS

	CAN1	CAN2	CAN3	CAN4
WBS1	-0.4099	-0.4231	-0.9162	0.6596
WBS2	-1.4790	-0.3922	-1.4576	-1.3643
WBS3	-2.5031	-2.1529	1.3484	-0.9230
WBS4	0.3461	0.3778	1.5689	-0.0538
WBS5	-1.9761	-1.2860	0.6464	-0.1727
WBS6	4.1641	1.0287	0.7166	0.4816
WBS7	-2.3151	0.8599	-2.1378	0.3761
WBS8	2.5154	1.1024	1.7614	0.3513
WBS9	-1.0215	-0.3459	-0.7573	0.8340
WBS10	-0.8915	-0.7201	-0.3387	-0.3203
WBS11	-1.1457	-0.6095	0.3604	-0.2956
WBS12	0.1259	0.0612	-1.2356	0.4893
WBS13	-0.1695	0.0293	-0.9320	0.1392
WBS14	-3.0376	0.4617	-2.6606	0.0018
WBS15	1.7975	-0.0557	3.3466	-0.6502
WBS16	4.3210	0.8382	1.0915	-0.1810
WBS17	0.0862	0.9068	-0.8581	0.9083
WBS18	0.2017	-0.7699	0.7845	0.1497
WBS19	1.1597	0.4115	0.1150	-0.0455
WBS20	-0.0645	-0.8201	-0.4479	-0.9213
WBS21	-0.8631	-0.4173	-2.1174	0.4096
WBS22	-0.9617	-0.9786	1.0223	-0.7062
WBS23	-2.3448	1.1745	-2.1638	-0.4072
WBS24	2.4483	-0.5499	0.8771	1.1050
WBS25	-1.0213	1.4725	-1.2463	0.7315
WBS26	-0.6613	-0.1893	0.2744	-1.3577
WBS27	0.0776	0.3962	0.4340	0.4782
WBS28	0.7073	0.0594	1.8908	-0.2461
WBS29	3.4750	0.2047	-0.6355	1.2137
WBS30	-0.2145	0.0101	0.8583	-0.2090
WBS31	-0.6274	-0.4578	0.6773	0.1636

• Project Characteristics.
WBS 1 = Size of project
WBS 2 = Type of project
WBS 3 = Tight project schedule
WBS 4 = Complexity of Design
WBS 5 = Quality Required
WBS 6 = Project Location.

• Project Documents.
WBS 7 = Contract clauses
WBS 8 = Completeness of plans and specs.
WBS 9 = Clarity of project objectives.

• Labor.
WBS 10 = Poor labor productivity
WBS 11 = Number of labor required/available
WBS 12 = Skill of labor required/available
WBS 13 = Labor relations problems.

• Equipment.
WBS 14 = Number of equipment required/available
WBS 15 = Type of equipment required/available

• Company Characteristics.
WBS 16 = Size of company
WBS 17 = Unfamiliarity with some construction process
WBS 18 = Use of Technology (computers)
WBS 19 = Timing of Resources Procurement
WBS 20 = Poor technical and administrative performance
WBS 21 = Reliability of budget estimate
WBS 22 = Number of supervisors required/available
WBS 23 = Work load (No. of projects available)
WBS 24 = Type of approach to project management
WBS 25 = Continuous change orders.

• Outside Influences.
WBS 26 = Continuous change in government rules and regulations
WBS 27 = Inflation
WBS 28 = Weather
WBS 29 = Unforeseen site conditions
WBS 30 = Claims
WBS 31 = Owner interference during construction

Table 23 : Standardized Canonical Coefficients for W.B.S.

From a review of the results of both methods, Company Characteristics appeared to be the most significant broad category of discrimination. The importance of this category can be explained in the light of the discriminating factors as follows:-

A) USE OF TECHNOLOGY:

Computers are normally utilized by the contractors who have enough projects that justify the corresponding expenses for construction cost control. The greater the size of the contractor, the more detailed is the breakdown for activities, and in turn the greater the need to utilize a computer system for data handling.

B) TIMING OF RESOURCES PROCUREMENT:

Normally, timing of resources procurement is a source of problems to every contractor. During the course of interviews, one contractor stated that one of the most important aspects in developing a cost control system is to develop a formal procurement program to guarantee the smooth running of the project. So the greater the size of the contractor, the more efficient the timing of procurement must be. This is also noticed in the hiring of qualified and specialized staff. This staff may form a separate department only for

procurement problems, which in turn may result in more detailed work activities. So the problems created by timing of resources procurement decrease as the size of contractors increases.

C) POOR TECHNICAL AND ADMINISTRATIVE PERFORMANCE:

Poor Technical and Administrative Performance forms an important discriminator. The importance of this factor lies in the ability of lower grade number contractors to hire qualified and well-educated personnel. In addition, these contractors always look forward to the newly released methods and techniques in administering as well as constructing their projects. So the bigger the size of contractor is, the fewer the problems faced resulting from poor technical and administrative performance, and vice versa for contractors of smaller size. This results in more detailed work activities to control project personnel performance for the contractors of lower grade numbers compared with the contractors of higher grade numbers.

D) NUMBER OF SUPERVISORS REQUIRED/AVAILABLE:

The problems created by the number of supervisors required, compared to the number available, decrease as the size of the contractor increases. This is due to the fact

that the contractors of higher grade numbers depend heavily on temporary employees and part-timers since they cannot afford to pay permanent employees. This shortage in the number of supervisors forces these contractors to use less detailed breakdown of work activities.

E) TYPE OF APPROACH TO PROJECT MANAGEMENT:

The degree of work breakdown structure is a subjective issue, which is decided by the project management according to the project conditions. Some project managers tend to go very deep in detailing the work to be done. However, an opposite tendency is shown by other managers.

F) SIZE OF COMPANY:

One of the factors that have a direct impact on the degree of work breakdown structure is the size of company itself. Because of the large number of employees as well as the ability to afford the required financial resources, employees of large companies become more specialized. This specialization is reflected in their highly defined roles and responsibilities, which in turn enable more detailed breakdown of work to be executed.

G) WORKLOAD:

Workload has an inverse relationship with the degree of W.B.S.. The more projects there are on hand, the greater the shortage of resources experienced. This situation usually limits the extent of detailing the work activities.

Project Characteristics contributes to discrimination as follows:

A) SIZE OF PROJECT:

Normally, the bigger the project is, the deeper the W.B.S. of activities. This is due to the complexity of work to be executed. So, when the size of the contractor gets bigger, more detailed work activities are produced.

B) TIGHT PROJECT SCHEDULE:

When the project schedule gets tight, it becomes necessary to define exactly what has to be done and when. This can be achieved by the detailed breakdown of work activities. However, excessive detail may also cause delay. This is due to the extensive planning efforts as well as difficulties in updating the schedule in case of deviation.

C) PROJECT LOCATION:

Knowing the location of the project aids in deciding how far the work should be detailed. Depending on the location of the project, each site has its own unique characteristics that make it different from the other sites. This uniqueness may be due to topography, weather, distance from the head office etc.

Project Documents contributes to discrimination as follows:

A) CONTRACT CLAUSES:

The contract clauses are normally incorporated to preserve the rights of all project parties. However, these clauses may be in the form of tough penalties for non-compliance or some other clause that may subject the contractor to financial hazards. Whenever such clauses are present, the contractor tends to use more detailed W.B.S.. However, the detailing of work activities may even be specified in the contract itself

B) COMPLETENESS OF PLANS AND SPECIFICATIONS:

Normally, if the plans and specifications are not complete, the contractor does not have enough information to

carry a detailed W.B.S.. So, the degree of such details depends on the quantity of information provided to the contractor.

Factors related to Labor contribute to discrimination as follows:

A) POOR LABOR PRODUCTIVITY:

If the labor productivity is less than what is required to execute a certain project, more workers are needed to finish the job within a specified time limit. To fit this additional number of labor, and to have full control over labor productivity, more detailed W.B.S. is needed. This need increases as the size of the contractor gets bigger, where time is normally a critical issue to execute large projects.

B) SKILL OF LABOR REQUIRED/AVAILABLE:

When the number of available skills is less than what is required, the contractor may be forced to assign more responsibilities to each worker. This creates less details in W.B.S.. However, sometimes if the required skill to execute a certain job is not available, more details of W.B.S. are provided to guide non-skilled labor.

Equipment contributes to discrimination as follows:

A) NUMBER OF EQUIPMENT REQUIRED/AVAILABLE:

If the available number of equipment is less than what is needed, less detailed W.B.S. are provided to suit the existing number.

Outside Influences contributes to discrimination as follows:

A) UNFORESEEN SITE CONDITIONS:

Normally, if the site conditions are clearly defined, more detailed work may be planned. On the other hand, if the site conditions are vague or the location of the site is known to suffer from unexpected circumstances, less detailed W.B.S. is usually produced.

4.2.2 Factors Affecting the Organization Breakdown Structure (O.B. S.):

The second important parameter in the level of control is the structure of organization itself. In setting an organization breakdown structure suitable to a certain project, the number of project personnel and their roles and responsibilities should be clearly defined

Table 24 and figure 25 rank the thirty-one factors according to their impact level on the organization breakdown structure. From this table, Project Characteristics is the most important broad category affecting the organization breakdown structure. On the other hand, Tight Project Schedule ranks first among the other thirty factors.

Figures 26-30 highlight the importance of these factors when classified according to the contractors' grades. From these figures, Company Characteristics is the most important category for the first grade, Labor for the second, Project Characteristics for the third, Project and Company Characteristics for the fourth and Project Documents for the fifth.

From Table 24, Use of Computers is the most important factor for the first grade, Size of Company for the second grade and Tight Project Schedule for the third, fourth and fifth grades contractors.

FACTORS	All Grades		Grade 5		Grade # 4		Grade 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
A. PROJECT CHARACTERISTICS		67.51		62.91		73.81		78.57		58.73		64.68
- Tight project schedule	1	76.82	1	73.68	1	83.33	1	100.0	19	52.38	20	66.67
- Size of project	2	73.65	5	63.91	7	77.38	5	80.00	3	80.95	3	88.10
- Complexity of design	8	67.94	7	61.65	15	70.24	12	68.57	8	71.43	9	80.95
- Type of project	18	62.54	6	62.41	8	77.38	17	62.86	30	28.57	29	50.00
- Project location	20	62.22	18	57.89	4	78.57	7	77.14	20	52.38	31	35.71
- Quality Required	21	61.90	17	57.89	30	55.95	2	82.86	11	66.67	21	66.67
B. PROJECT DOCUMENTS		64.55		63.16		65.87		71.43		50.79		67.46
- Contract clauses	5	69.21	2	67.67	5	78.57	3	82.86	29	33.33	25	61.90
- Completeness of plans and spec's.	19	62.54	8	61.65	25	61.90	18	62.86	21	52.38	16	71.43
- Clarity of project objectives.	22	61.90	10	60.15	29	57.14	13	68.57	12	66.67	19	69.05
C. LABOR		65.24		59.78		71.43		60.00		66.74		73.81
- Skill of labor required/ available.	4	69.84	4	65.41	13	75.00	26	54.29	4	76.19	7	83.33
- Number of labor required/ available.	9	67.62	11	60.15	10	76.19	24	60.00	6	71.43	10	78.57
- Poor labor productivity	10	66.98	13	59.40	17	69.05	8	74.29	5	71.43	11	78.57
- Labor relations problems	28	56.51	23	54.14	21	65.48	28	51.43	24	47.62	28	54.76
D. EQUIPMENT		55.40		54.88		61.31		55.72		30.96		57.14
- Type of equipment required/available.	29	56.51	19	57.14	23	83.10	25	57.14	31	23.81	27	57.14
- Number of equipment required/available.	30	54.28	27	52.63	27	59.52	27	54.29	27	38.10	26	57.14

Table 24 : Factors Importance Index for O.B.S.

FACTORS	All Grades		Grade # 5		Grade # 4		Grade # 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
E. COMPANY CHARACTERISTICS		66.13		56.17		73.81		66.86		65.71		81.91
- Size of company	3	73.65	3	66.92	11	76.19	19	62.86	1	95.24	4	88.10
- Type of approach to project management	6	69.21	15	58.65	3	79.76	10	71.43	17	57.14	6	85.71
- Number of supervisors required/available	7	68.25	16	58.65	6	78.57	15	65.71	2	80.95	15	73.81
- Timing of resources procurement	11	66.98	9	60.15	12	76.19	21	62.86	16	57.14	12	78.57
- Work load (No. of projects available).	12	60.67	26	52.63	2	82.14	6	80.00	13	61.90	18	71.43
- Poor technical and administrative performance	13	65.71	30	47.37	9	77.38	9	74.29	10	66.67	2	92.86
- Unfamiliarity with some construction process	14	65.08	22	54.89	16	70.24	4	82.86	9	66.67	17	71.43
- Use of technology(computers)	15	63.49	25	53.38	26	60.71	20	62.86	7	71.43	1	97.62
- Reliability of budget estimate	17	62.86	12	60.15	18	69.05	30	42.86	25	42.86	5	85.71
- Continuous change orders	25	59.36	28	48.87	20	67.86	22	62.86	18	57.14	13	73.81
F. OUTSIDE INFLUENCES		58.20		53.76		63.49		58.57		51.59		64.68
- Owner interference during construction.	16	63.49	14	59.40	19	69.05	16	65.71	14	61.90	24	64.28
- Claims	23	60.00	29	48.87	14	71.43	23	62.86	23	52.38	14	73.81
- Inflation	24	59.68	20	56.39	24	61.90	11	71.43	26	42.86	23	64.28
- Unforeseen site conditions	26	58.10	21	56.39	28	59.52	31	37.14	22	52.38	8	80.95
- Continuous change in governmental rules and regulations.	27	57.78	31	47.37	22	65.48	14	68.57	15	61.90	22	64.28
- Weather	31	50.16	24	54.14	31	53.57	29	45.72	28	38.10	30	40.48

Table 24 : Factors Importance Index for O.B.S. (cont'd.)

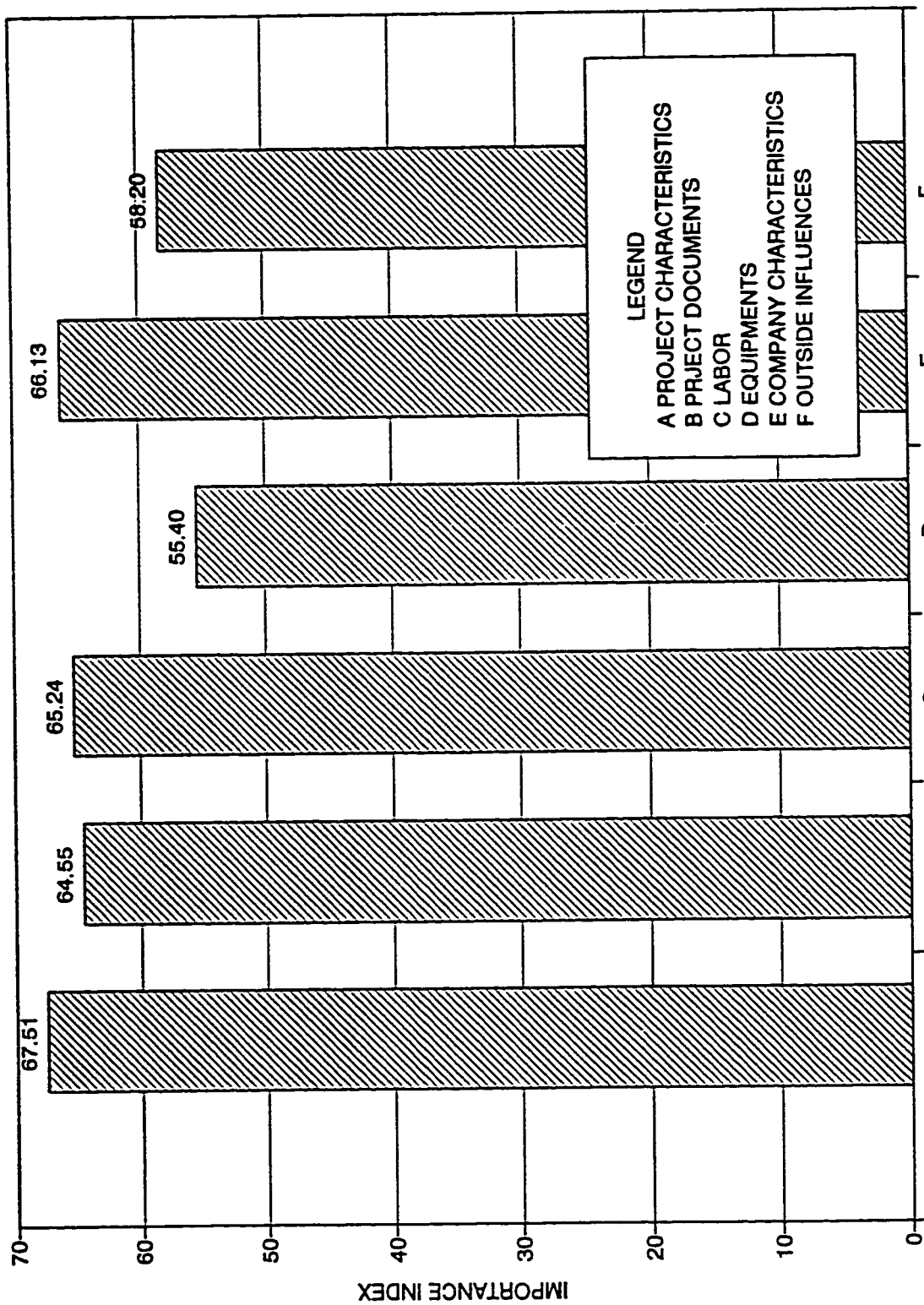


Fig. 25 : O.B.S. Importance Index for all Grades (Broad Categories).

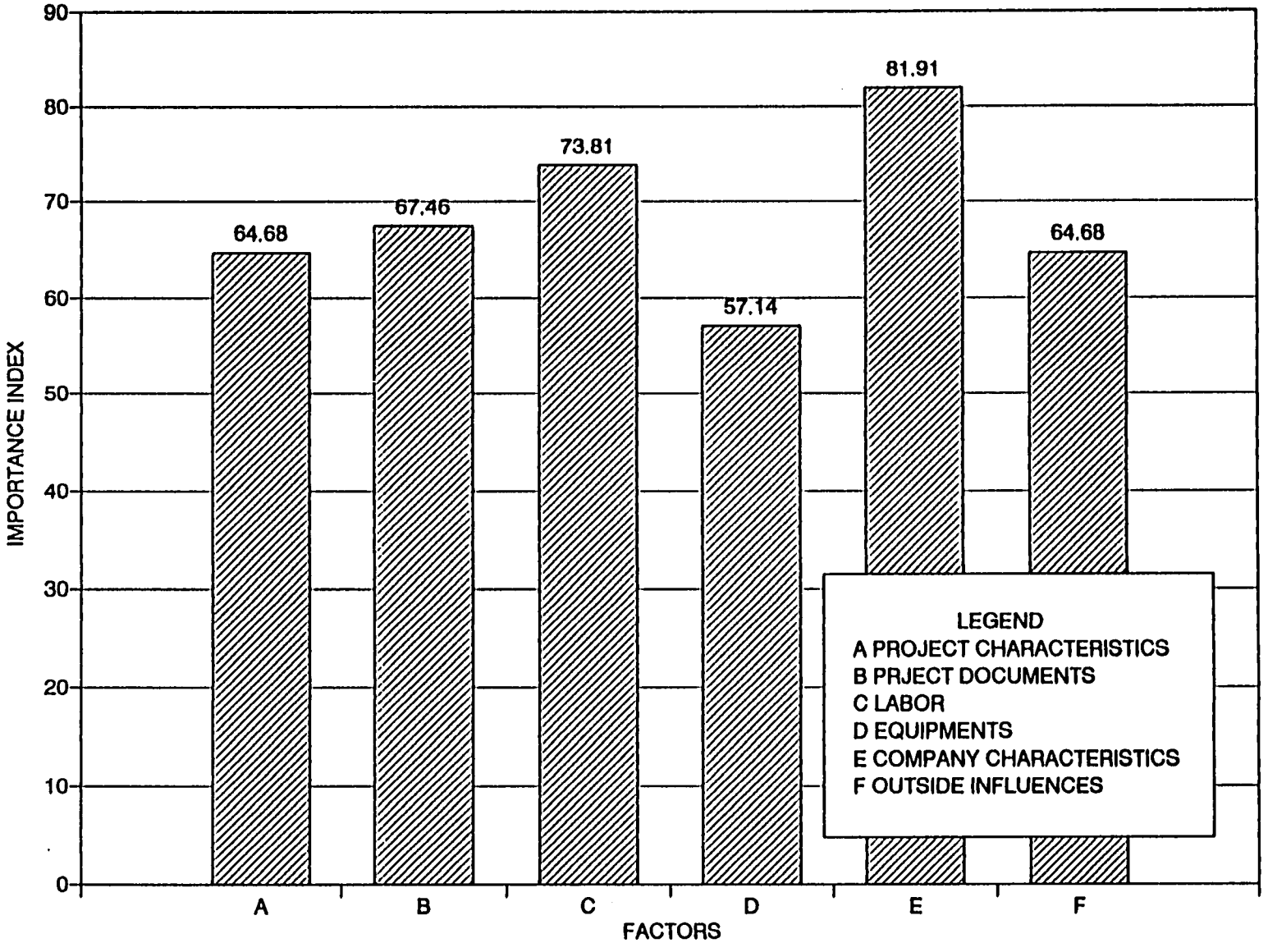


Fig. 26 : O.B.S. Importance Index for Grade#1 (Broad Categories).

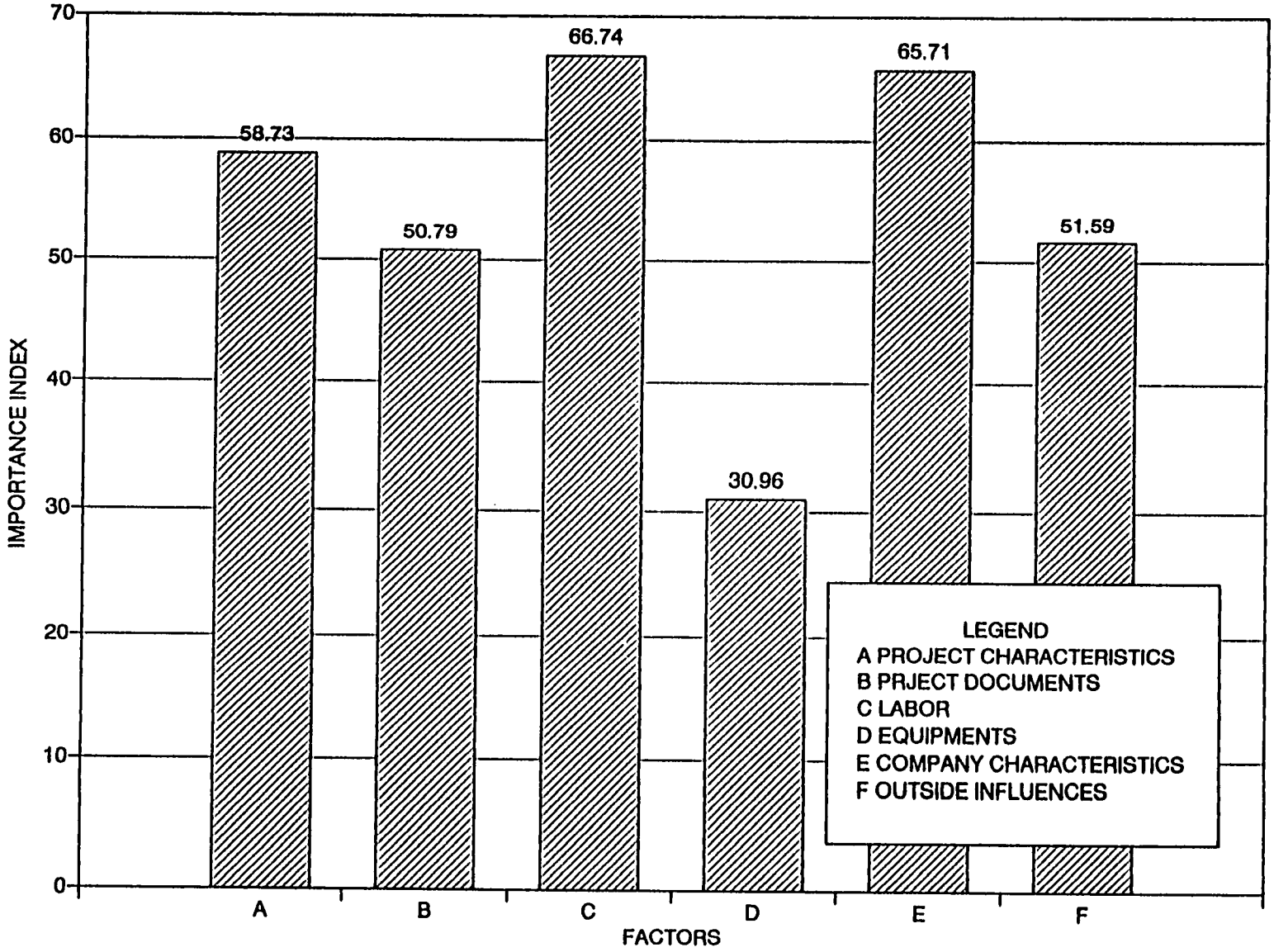


Fig. 27 : O.B.S. Importance Index for Grade#2 (Broad Categories).

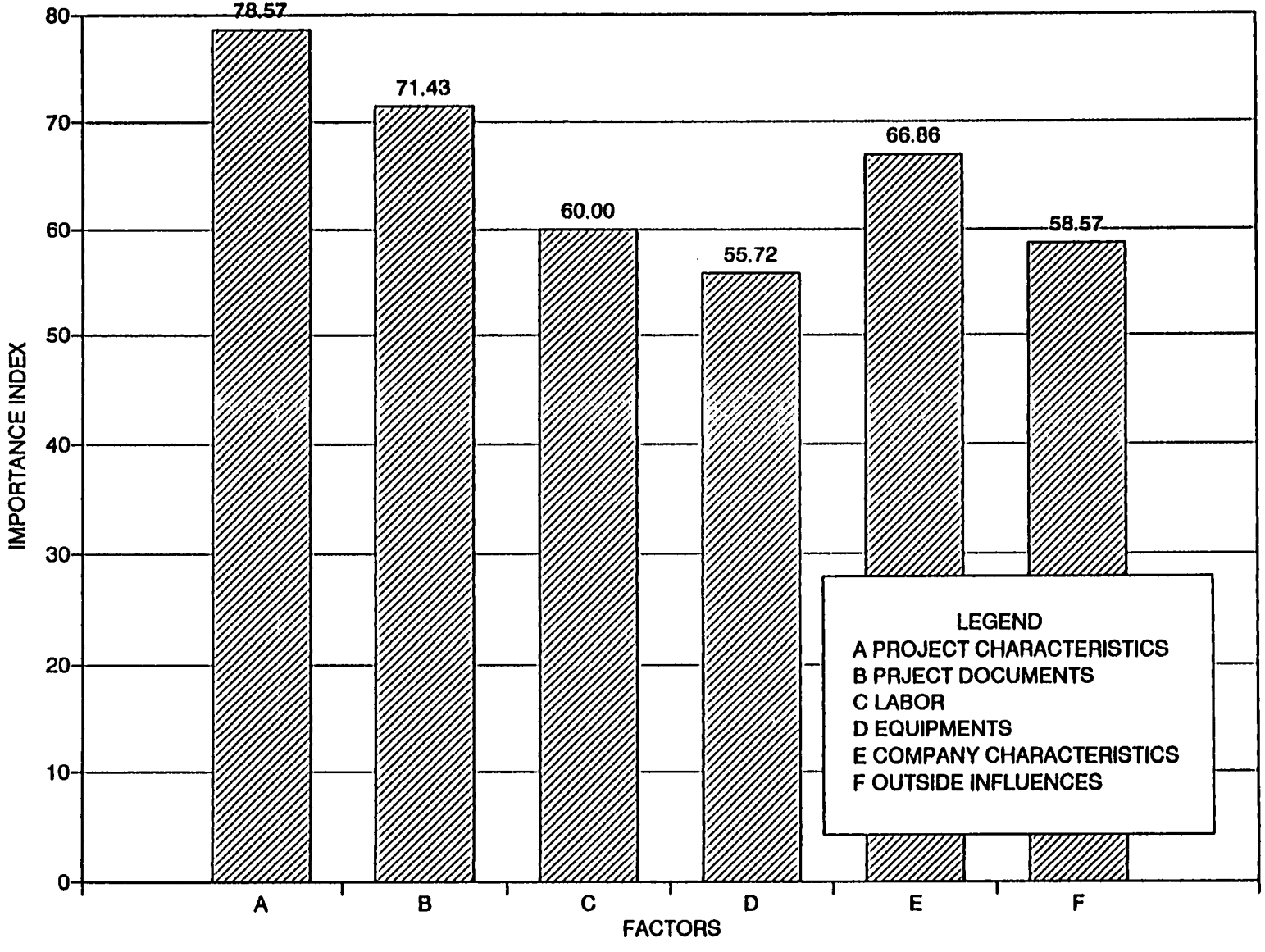


Fig. 28 : O.B.S. Importance Index for Grade#3 (Broad Categories).

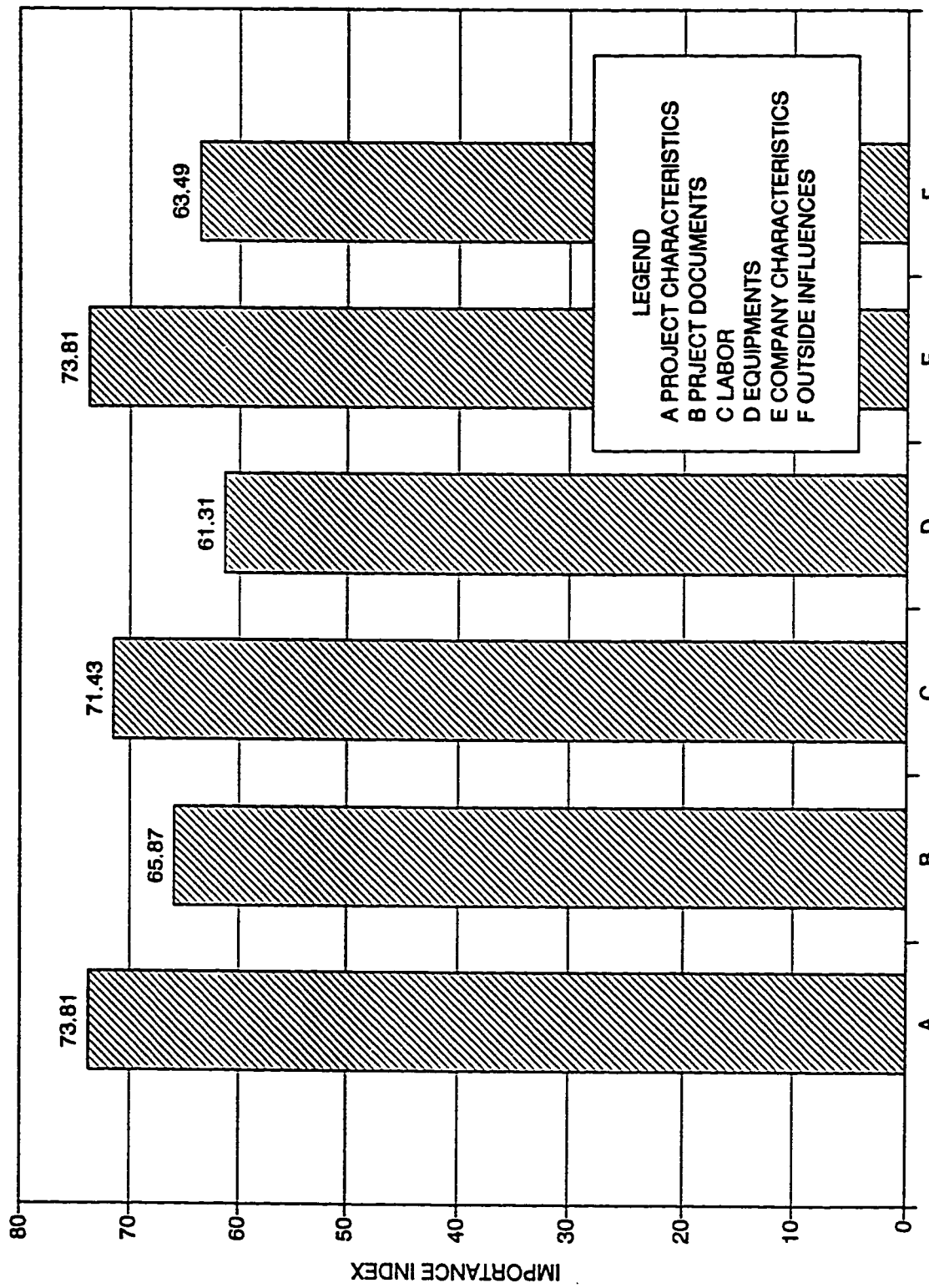


Fig. 29 : O.B.S. Importance Index for Grade#4 (Broad Categories).

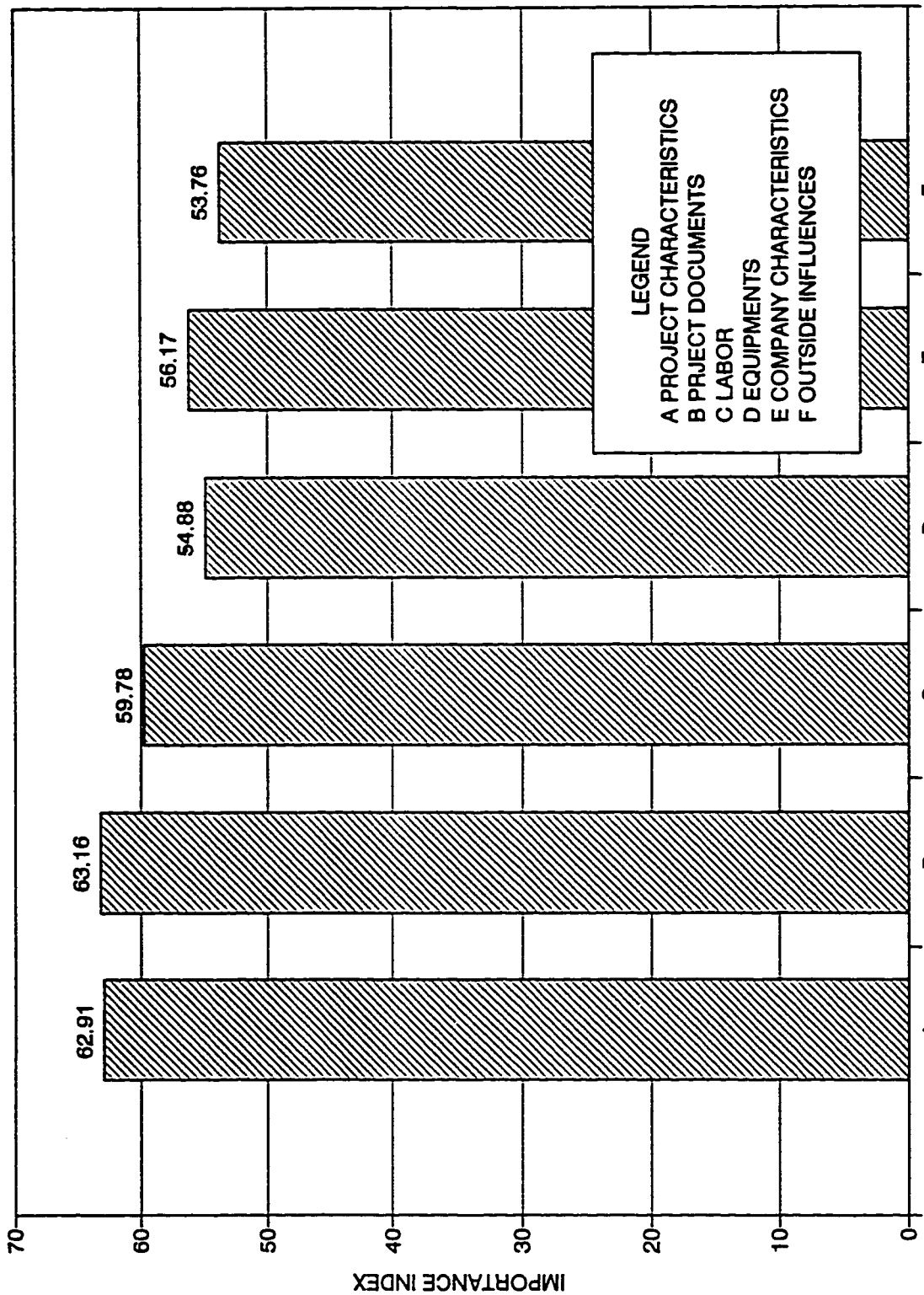


Fig. 30 : O.B.S. Importance Index for Grade#5 (Broad Categories).

Table 25 summarizes the results of the Discriminant Analysis. for O.B.S. From this figure, the following can be observed:

1) Canonical Correlation for Function 1 = 0.965
2) Canonical Correlation for Function 2 = 0.888
3) Canonical Correlation for Function 3 = 0.858
4) Canonical Correlation for Function 4 = 0.706

According to the above, the degree of association between the five grades and (CAN1, CAN2, CAN3 & CAN4) is very high; which suggests the the use of the contractors' grades is a good discriminator.

By examining the Eigen value:

* Eigen value for Function 1 = 13.444
* Eigen value for Function 2 = 3.722
* Eigen value for Function 3 = 2.801
* Eigen value for Function 4 = 0.993

Functions 1 & 2 have the highest Eigen values. This indicates that these two functions are the most powerful discriminators, Function 1 contributes to 64.1% of the discriminating power and Function 2 contributes to 17.8%.

5) Square Canonical Correlation for Function 1 = 0.931
6) Square Canonical Correlation for Function 2 = 0.788

CANONICAL DISCRIMINANT ANALYSIS

45 OBSERVATIONS	44 DF TOTAL
31 VARIABLES	40 DF WITHIN CLASSES
5 CLASSES	4 DF BETWEEN CLASSES

	CANONICAL CORRELATION	ADJUSTED CANONICAL CORRELATION	APPROX STANDARD ERROR	SQUARED CANONICAL CORRELATION	EIGENVALUE	EIGENVALUES OF INV(E)*H = CANRSQ/(1-CANRSQ) DIFFERENCE	PROPORTION
1	0.964762	0.937426	0.010438	0.930765	13.4436	9.7213	0.6414
2	0.887830	0.789577	0.031924	0.788242	3.7224	0.9216	0.1776
3	0.859425	0.779164	0.039665	0.738893	2.8007	1.9082	0.1336
4	0.705779	0.507660	0.075661	0.498122	0.9925	.	0.0474

TESTS OF H0: THE CANONICAL CORRELATION IN THE CURRENT ROW AND ALL THAT FOLLOW ARE ZERO

	LIKELIHOOD RATIO	APPROX F	NUM DF	DEN DF	PR > F
1	0.00193594	1.3030	124	42.3964	0.1626
2	0.02796208	0.8656	90	33.808	0.7096
3	0.13204744	0.7249	58	24	0.8408
4	0.50187758	0.4608	28	13	0.9581

MULTIVARIATE TEST STATISTICS AND F APPROXIMATIONS
S=4 M=13 N=4

STATISTIC	VALUE	F	NUM DF	DEN DF	PR > F
WILKS' LAMBDA	0.001935944	1.303	124	42.3964	0.1626
PILLAI'S TRACE	2.954023	1.184	124	52	0.2478
HOTELLING-LAWLEY TRACE	20.95927	1.437	124	34	0.1111
ROY'S GREATEST ROOT	13.44364	5.638	31	13	0.0010

NOTE: F STATISTIC FOR ROY'S GREATEST ROOT IS AN UPPER BOUND

Table 25 : Canonical Discriminant Analysis O.B.S.

7) Square Canonical Correlation for Function 3 = 0.737

8) Square Canonical Correlation for Function 4 = 0.498

From the above Square Canonical correlations, it can be verified that the proportion of variation in the discriminant functions is explained by the groups especially for the first two functions (41).

5) Wilk's Lambda = 0.002

This very small value suggests a high degree of discrimination between the groups, which is not due to sampling (41). This high degree of discrimination can be visualized by the centroids of the groups allocated on the plot of CAN1 & CAN2 (Fig. 31).

To study the factors which contribute most to the discrimination, the previously illustrated two methods can be used:-

1) TOTAL CANONICAL STRUCTURE:

Table 26 illustrates the total canonical structure for functions 1 & 2.

For (CAN1), the discriminating factors are: Project Location, Poor Technical and Administrative Performance and Work Load (number of projects available).

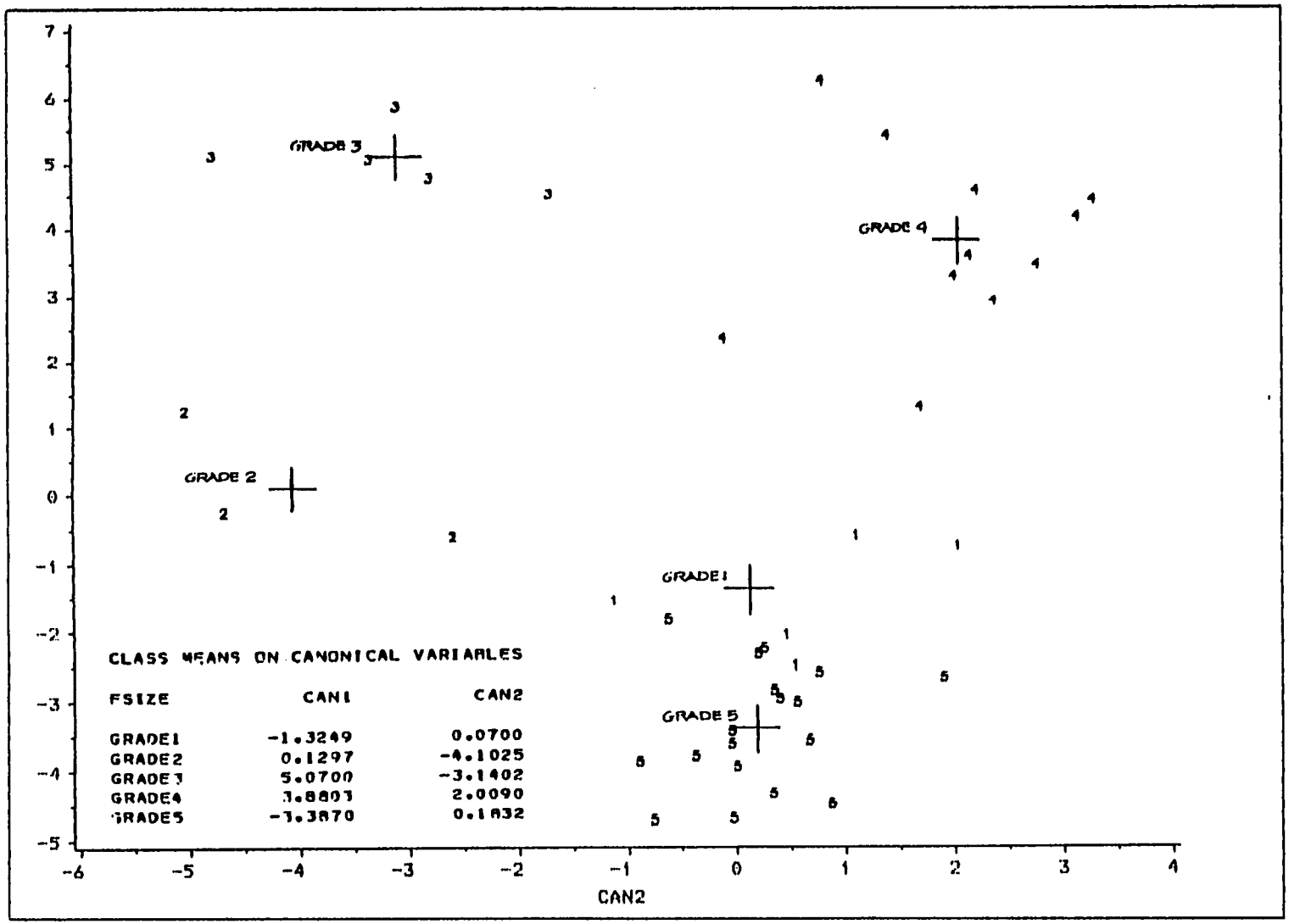


Figure 31 : Plot of (CAN1 & CAN2) for O.B.S.

CANONICAL DISCRIMINANT ANALYSIS

TOTAL CANONICAL STRUCTURE

	CAN1	CAN2	CAN3	CAN4
OBS1	0.1949	-0.0604	0.2181	0.2061
OBS2	0.1704	0.3391	-0.2452	-0.0319
OBS3	0.2988	0.0417	-0.3671	0.1211
OBS4	0.1051	-0.0071	0.1987	0.1885
OBS5	0.1142	-0.2691	-0.0497	0.1961
OBS6	0.3321	0.1076	-0.2483	-0.2644
OBS7	0.2100	0.2094	-0.3165	0.1493
OBS8	-0.0098	0.0544	0.0151	0.2129
OBS9	0.0012	-0.1318	0.0448	0.1324
OBS10	0.1489	-0.0639	0.1410	0.1807
OBS11	0.1361	0.1207	0.2482	0.0748
OBS12	0.0063	0.1398	0.3151	0.0636
OBS13	0.0991	0.1614	0.0107	-0.0259
OBS14	0.0807	0.1665	-0.0487	0.1326
OBS15	0.0650	0.2812	-0.1955	0.1941
OBS16	0.0435	-0.0274	0.4230	0.0271
OBS17	0.2829	-0.0930	0.0518	0.1721
OBS18	0.0464	-0.0710	0.3480	0.4051
OBS19	0.1756	0.2112	0.1698	0.2085
OBS20	0.3494	0.0345	0.3248	0.3767
OBS21	-0.0539	0.3373	0.2323	0.3222
OBS22	0.2527	0.0531	0.2813	-0.0329
OBS23	0.4130	0.0779	0.0907	0.1310
OBS24	0.2491	0.1594	0.1705	0.3024
OBS25	0.2309	0.0671	0.1924	0.2221
OBS26	0.2641	-0.0297	0.1149	0.1110
OBS27	0.1179	0.0285	-0.0929	0.2076
OBS28	-0.0325	0.1515	-0.1522	-0.1175
OBS29	-0.1283	0.2150	0.3119	0.2563
OBS30	0.2464	0.1228	0.1603	0.2131
OBS31	0.1237	0.0468	0.0339	0.0190

* Project Characteristics.
OBS 1 = Size of project
OBS 2 = Type of project
OBS 3 = Tight project schedule
OBS 4 = Complexity of Design
OBS 5 = Quality Required
OBS 6 = Project Location.

* Project Documents.
OBS 7 = Contract clauses
OBS 8 = Completeness of plans and specs.
OBS 9 = Clarity of project objectives.

* Labor.
OBS 10 = Poor labor productivity
OBS 11 = Number of labor required/available
OBS 12 = Skill of labor required/available
OBS 13 = Labor relations problems.

* Equipment.
OBS 14 = Number of equipment required/available
OBS 15 = Type of equipment required/available

* Company Characteristics.
OBS 16 = Size of company
OBS 17 = Unfamiliarity with some construction process
OBS 18 = Use of Technology (computers)
OBS 19 = Timing of Resources Procurement
OBS 20 = Poor technical and administrative performance
OBS 21 = Reliability of budget estimate
OBS 22 = Number of supervisors required/available
OBS 23 = Work load (No. of projects available)
OBS 24 = Type of approach to project management
OBS 25 = Continuous change orders.

* Outside Influences.
OBS 26 = Continuous change in government rules and regulations
OBS 27 = Inflation
OBS 28 = Weather
OBS 29 = Unforeseen site conditions
OBS 30 = Claims
OBS 31 = Owner interference during construction

Table 26 : Total Canonical Structure for O.B.S.

For (CAN2), the discriminating factors are: Type of Project and Reliability of Budget Estimate.

From the previous analysis, five factors are considered the greatest contributors to discrimination. From broad categories perspective, the following can be observed:

- 40% (2/5) of the factors contributing to discrimination are related to Project Characteristics.
- 0.0% of the factors contributing to discrimination are related to Project Documents.
- 0.0% of the factors contributing to discrimination are related to Labor.
- 0.0% of the factors contributing to discrimination are related to Equipment.
- 60% (3/5) of the factors contributing to discrimination are related to Company Characteristics.
- 0.0% of the factors contributing to discrimination are related to Outside Influences.

2) STANDARD CANONICAL COEFFICIENTS:

Table 29 lists the standardized canonical coefficients for the first two functions. The most discriminating factors

for CAN1 are nineteen: Size of Project, Type of Project, Tight Project Schedule, Quality Required, Project Location, Contract Clauses, Clarity of Project Objectives, Number and Skill of Labor Required/Available, Unfamiliarity with Some Construction Process, Use of Technology (computers), Poor Technical and Administrative Performance, Type of Approach to Project Management, Continuous Change Orders, Continuous Change in Government Rules and Regulations, Inflation, Weather, Claims and Owner Interference During Construction.

For CAN2, ten factors are most discriminating. These factors are: Size of Project, Type of Project, Complexity of Design, Completeness of Plans and Specifications, Clarity of Project Objectives, Skill of Labor Required/Available, Poor Technical and Administrative Performance, Number of Supervisors Required/Available, Work Load (no. of projects available) and Continuous Change Orders. Generally speaking twenty-three factors are significant discriminators.

CANONICAL DISCRIMINANT ANALYSIS

STANDARDIZED CANONICAL COEFFICIENTS

	CAN1	CAN2	CAN3	CAN4
OBS1	-2.8732	-3.0524	-1.2287	0.2196
OBS2	4.1568	2.7745	0.9008	-0.3682
OBS3	4.8488	0.3658	-0.3811	-0.0934
OBS4	0.3604	2.7003	1.5841	-0.1785
OBS5	4.5939	0.4170	-0.0710	0.1746
OBS6	-2.0821	-0.6732	0.7002	-0.9725
OBS7	-3.8013	-0.7587	-1.3014	1.2341
OBS8	0.8983	2.2114	0.1734	-0.6942
OBS9	-5.7712	-4.2030	-1.6178	0.8372
OBS10	0.4695	1.2102	0.2929	0.6564
OBS11	4.9847	1.6787	0.6405	0.5937
OBS12	-3.8650	-2.1719	0.3477	-0.7183
OBS13	0.2659	0.1795	-0.4013	0.8200
OBS14	0.4691	-0.1172	-1.0444	-0.7533
OBS15	0.2173	-1.0476	-0.0799	0.5401
OBS16	1.5936	-1.6349	1.0879	-0.0458
OBS17	-2.4448	-1.0222	-0.1635	0.9745
OBS18	-2.3552	-1.3191	1.0101	0.0286
OBS19	-1.2970	-0.0821	-0.2023	-0.3797
OBS20	4.2139	2.1666	0.8071	-0.3194
OBS21	1.5022	0.7909	-0.0655	0.2507
OBS22	1.7177	2.0707	0.0784	-1.3630
OBS23	1.7594	-2.1416	-0.7449	0.4552
OBS24	-2.4586	1.6066	-0.4052	1.0779
OBS25	-3.0686	-2.1334	0.6378	0.3255
OBS26	6.7034	1.3848	0.9416	-0.7244
OBS27	-3.7771	-1.6240	-0.6899	0.2437
OBS28	-2.5367	1.2233	-0.3887	-0.6989
OBS29	-1.7927	1.6612	0.5049	0.7909
OBS30	2.2339	0.3279	-0.4078	0.0020
OBS31	-2.3626	-0.5706	0.0547	-1.1815

* Project Characteristics.
OBS 1 = Size of project
OBS 2 = Type of project
OBS 3 = Tight project schedule
OBS 4 = Complexity of Design
OBS 5 = Quality Required
OBS 6 = Project Location.

* Project Documents.
OBS 7 = Contract clauses
OBS 8 = Completeness of plans and specs.
OBS 9 = Clarity of project objectives.

* Labor.
OBS 10 = Poor labor productivity
OBS 11 = Number of labor required/available
OBS 12 = Skill of labor required/available
OBS 13 = Labor relations problems.

* Equipment.
OBS 14 = Number of equipment required/available
OBS 15 = Type of equipment required/available

* Company Characteristics.
OBS 16 = Size of company
OBS 17 = Unfamiliarity with some construction process
OBS 18 = Use of Technology (computers)
OBS 19 = Timing of Resources Procurement
OBS 20 = Poor technical and administrative performance
OBS 21 = Reliability of budget estimate
OBS 22 = Number of supervisors required/available
OBS 23 = Work load (No. of projects available)
OBS 24 = Type of approach to project management
OBS 25 = Continuous change orders.

* Outside Influences.
OBS 26 = Continuous change in government rules and regulations
OBS 27 = Inflation
OBS 28 = Weather
OBS 29 = Unforeseen site conditions
OBS 30 = Claims
OBS 31 = Owner interference during construction

Table 27 : Standardized Canonical Coefficients for O.B.S.

According to this method, the broad categories contribute to discrimination as follows:

- 26.1% (6/23) of the discrimination is related to Project Characteristics.

- 13.0% (3/23) of the discrimination is related to Project Documents.

- 8.7% (2/23) of the discrimination is related to Labor.

- 0.0% of the discrimination is related to Equipment.

- 30.4% (7/23) of the discrimination is related to Company Characteristics.

- 21.7% (5/23) of the discrimination is related to Outside Influences.

A very important point to be observed is that both methods agree that Company Characteristics is the most important discriminator among the other broad categories.

The importance of Company Characteristics on the organization breakdown structure can be highlighted by analyzing its constituent important factors:

A) UNFAMILIARITY WITH SOME CONSTRUCTION PROCESS:

The relationship between unfamiliarity with some construction process and organization breakdown structure is apparent by the fact whenever there is a deficiency of knowledge about one aspect or part of the constructed project, the organization structure is adapted to suit the new methods and techniques. This adaptation is represented by recruiting qualified personnel, assigning the project to persons in the organization who are well acquainted with the unfamiliar parts of the project etc. Since most of the projects handled by contractors of higher grade numbers are typical, this problem is normally faced by the low grade numbers, specially first and second. In addition, these contractors are often involved with projects designed outside the Kingdom, which increases the possibility of exposure to different new construction techniques. In brief, the lower grade number of the contractor is, the more pronounced are the effects o unfamiliarity with some construction process.

B) USE OF TECHNOLOGY:

The effect the use of computer has on the organization structure is seen by the ease with which a contractor updates the organization structure continuously to suit the new projects. However, this phenomenon is more noticeable in

lower grade number contractors (the first and second). This is mainly due to the great number of personnel involved either in a single project or in the company as a whole.

C) POOR TECHNICAL AND ADMINISTRATIVE PERFORMANCE:

Poor technical and administrative performance is a serious problem. Whenever this type of problem arises, the organization structure should be updated to eliminate or at least minimize this deficiency. For big contractors, this procedure is possible because of the high number of personnel involved. However, this may not be applied to small contractors because of the limited number of personnel involved.

D) RELIABILITY OF BUDGET ESTIMATE:

Reliability of budget estimate is an issue that should be figured out at the beginning of the project. As was previously mentioned, some low grade number contractors make their project estimate outside the Kingdom. As a result, the reliability of the assigned budget estimate is questionable. Because of the large size of projects handled, tighter control over the project should be applied by exactly defining the roles and responsibilities of each person involved in the project. For small contractors, this problem is not serious due to the small and typical projects involved in.

E) NUMBER OF SUPERVISORS REQUIRED/AVAILABLE:

Whenever a shortage in the number of supervisors required for a certain project is experienced, the organization structure is updated accordingly. This is achieved by assigning more roles and responsibilities to each supervisor.

F) NUMBER OF PROJECTS AVAILABLE:

The number of projects available has a great effect on the organization structure. The more projects available, the more personnel are needed and the more the responsibilities which are assigned to each person. On the other hand, a smalle number of personnel is needed for a small number of projects. A prime example is the economic boom in the seventies, where each person had many responsibilities to cope with the projects available. However, during the economic depression in the eighties, many employees were retired and even some companies liquidated.

G) TYPE OF APPROACH TO PROJECT MANAGEMENT:

The type of approach to project management has a pronounced effect on the organization structure. For example, big contractors are observed to depend on a professional construction management approach while small contractors depend on the classical way of construction management.

H) CONTINUOUS CHANGE ORDERS:

Continuous change orders are mostly noticed in third, fourth and fifth grade contractors. However, because of a clear scope of work, these change orders are less for first and second grad contractors. This fact leads higher grade number contractors to form a flexible organization structure to cope with the continuous change orders.

The effect of Project Characteristics on the O.B.S. can be explained as follows:

A) PROJECT LOCATION:

Many factors related to project location can affect the number of project personnel and their roles and responsibilities. Such factors include, among others, accessibility, topography, local rules and regulations ...etc. For example, if the site is located in a remote area, project management should keep project personnel to th minimum to avoid mobilization problems.

B) QUALITY REQUIRED:

The number of personnel involved in a project is directly related to the quality required. To achieve the required quality, it may be necessary to assign specialized people.

This situation forms one guideline in forming the organization structure for that particular project

C) TIGHT PROJECT SCHEDULE:

When the project schedule is tight, the project organization structure should be organized to minimize its duration. Usually this can be achieved by assigning more people to do the job. In addition, the lines of communications among project personnel should be precise, clear and simple in order to avoid any complications.

D) SIZE OF PROJECT:

The bigger the project is, the greater the number of project personnel involved. This in turn creates more organizational levels as well as more lines of communications.

E) TYPE OF PROJECT AND COMPLEXITY OF DESIGN:

Projects differ according to type and complexity. When the project is of special importance, complex or requiring special skills, more people and/or more qualified people may be needed. In addition, the lines of communication among project personnel should provide an accurate, fast and smooth flow of information.

The effect of the Project Documents on the O.B.S. can be interpreted as follows:

A) CONTRACT CLAUSES:

Sometimes the contract itself forms a guideline in forming an organization structure, specially in big projects. So the lower the contractor's grade number is, the more detailed are the guidelines for forming the project organization structure provided in the project contract.

B) COMPLETENESS OF PLANS AND SPECIFICATIONS:

When the plans and specifications are complete, clearer and more precise delineation of responsibilities can be achieved. Normally, the bigger the project size is, the more complete plans and specifications which are required, and vice versa for smaller projects.

C) CLARITY OF PROJECT OBJECTIVES:

When the project objectives are clear, more detailed and accurate delineation of roles and responsibilities of the project personnel is possible. In addition, with such clear project objectives, the number of organizational levels required can be easily predicted.

The impact of Labor on O.B.S. can be explained as follows:

A) NUMBER OF LABOR REQUIRED/AVAILABLE:

When a shortage in the number of labor is experienced, fewer levels in the project organizational hierarchy are produced. This is mainly due to the more roles and responsibilities assigned to each worker. This situation also creates fewer and more simplified lines of communications.

B) SKILL OF LABOR REQUIRED/AVAILABLE:

Normally, when a certain skill required to execute a certain task or job is not available, the project organization structure is arranged in a way that a close monitoring of labor performance is achieved, and in turn work deficiencies are minimized.

The effects of Outside Influences are as follows:

A) OWNER INTERFERENCE DURING CONSTRUCTION

Owners differ in the degree of their interference during construction. The contractors who usually suffer from frequent owner interference during construction adopt a flexible organization hierarchy for ease of updating the work as required.

B) CONTINUOUS CHANGE IN GOVERNMENT RULES AND REGULATIONS:

When the project is located in an area which suffers from continuous change in rules and regulations, the organization structure should be flexible in order to cope with such changes.

C) INFLATION:

When the project is located in an area that suffers or is expected to suffer from inflation, the organization structure should be simple with the minimum number of employees. This practice helps in cutting the costs involved in too many organizational levels.

D) WEATHER:

If the project suffers or is expected to suffer from harsh weather conditions, the O.B.S. should be designed in a way to face the the resultant low efficiency of project personnel. To lower the burden on project personnel, more people are assigned to do the job.

E) CLAIMS:

If the type of project handled is known to be exposed to frequent claims among project parties, a more flexible organization structure should be formed. However, to avoid

being exposed to claims, roles and responsibilities as well as lines of communications should be clearly defined.

4.2.3 Factors Affecting the Frequency of Reporting (Freq. of Rep.):

Reporting the project status during construction is considered one of the most powerful tools for communication among project personnel. These reports which may go from up to down or vice versa differ in their frequencies. Generally, more frequent reports aid in maintaining tighter control over project cost.

Table 28 and Figure 32 illustrate the importance of the factors on the frequency of reporting for all grades. From Table 28 Labor and Company Characteristics are the most important categories. On the other hand, Tight Project Schedule is the most important category among the other thirty factors.

Figures 33-37 summarize the importance of these factors among the five contractor grades. From these figures, Company Characteristics is the most important for the first, second and fourth grades. For the third grade Project Documents is the most important. Lastly, Labor is the most important for the fifth grade.

From Table 28, Use of Computers is the most important factor for the first grade, Size of Company for the second, Size of Project for the third, Tight Project Schedule for the fourth and Poor Labor Productivity for the fifth.

FACTORS	All Grades		Grade # 5		Grade # 4		Grade # 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
A. PROJECT CHARACTERISTICS		63.39		57.52		68.06		67.14		60.32		71.03
- Tight project schedule	1	79.05	2	68.42	1	84.52	4	82.86	4	85.71	2	95.24
- Size of project	5	71.43	11	57.89	9	76.19	1	91.43	15	66.67	4	90.48
- Quality Required	21	59.05	10	58.65	27	60.71	19	60.00	25	47.62	24	61.90
- Complexity of design	25	57.46	9	59.40	31	48.81	24	57.14	17	61.90	21	66.67
- Project location	26	56.83	25	48.87	18	69.05	29	54.28	20	52.38	25	61.90
- Type of project	27	56.51	21	51.88	17	69.05	23	57.14	24	47.62	29	50.00
B. PROJECT DOCUMENTS		65.08		59.15		63.89		86.67		53.97		73.81
- Completeness of plans and spec's.	6	70.16	6	61.65	14	70.24	3	88.57	12	71.43	12	80.95
- Contract clauses	10	66.98	3	64.66	22	66.67	2	88.57	28	42.86	19	69.05
- Clarity of proj.objectives	23	58.10	22	51.13	30	54.76	5	82.86	26	47.62	16	71.43
C. LABOR		65.38		62.60		70.54		58.57		67.86		68.46
- Poor labor productivity	2	72.06	1	70.68	5	77.38	17	62.86	6	80.95	20	69.05
- Skill of labor required/ available	12	65.08	4	64.66	20	67.86	25	57.14	16	66.70	22	66.67
- Number of labor required/ available	13	64.44	5	62.41	15	70.24	30	45.71	13	71.43	17	71.43
- Labor relations problems	19	60.00	19	52.63	21	66.67	8	68.57	21	52.38	23	66.67
D. EQUIPMENT		54.44		50.38		61.31		68.57		40.48		48.81
- Type of equipment required/available	29	54.60	17	54.14	28	60.71	10	68.57	31	28.57	30	45.34
- Number of equipment required/available.	30	54.28	26	46.62	26	61.90	9	68.57	22	52.38	28	52.38

Table 28 : Factors Importance Index for Freq. Of Rep.

FACTORS	All Grades		Grade # 5		Grade # 4		Grade # 3		Grade # 2		Grade # 1	
	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.	Rank	Imp.
E. COMPANY CHARACTERISTICS		65.37		52.93		74.52		64.28		73.81		83.10
- Timing of resources procurement	3	72.06	7	60.90	8	76.19	7	74.28	2	90.48	6	88.10
- Continuous change orders	4	71.75	14	55.64	2	84.52	6	82.86	14	66.67	5	90.48
- Number of supervisors required/available	7	68.89	8	60.90	10	76.19	14	65.71	3	90.48	18	71.43
- Type of approach to project management	9	67.62	20	52.63	3	83.33	27	57.14	9	76.19	7	88.10
- Poor technical and administrative performance	11	65.40	24	50.38	6	77.38	13	65.71	8	80.95	11	80.95
- Size of company	14	64.44	23	50.38	11	73.81	26	57.14	1	90.48	8	83.33
- Work load (No. of projects available)	15	64.13	18	53.38	13	71.43	18	62.86	27	47.62	3	92.86
- Use of technology (computers)	16	62.86	28	44.36	19	67.86	12	68.57	7	80.95	1	97.62
- Unfamiliarity with some construction process	22	58.41	27	45.86	24	64.28	11	68.57	18	61.90	14	76.19
- Reliability of budget estimate.	24	58.10	15	54.89	16	70.24	31	40.00	23	52.38	26	61.90
F. OUTSIDE INFLUENCES		59.95		49.12		70.44		61.43		63.49		70.24
- Owner interference during construction.	8	67.94	12	57.14	4	83.33	28	57.14	19	61.90	10	83.33
- Unforeseen site conditions	17	62.86	13	57.14	25	64.28	22	60.00	11	76.19	15	73.81
- Claims	18	61.59	30	42.86	12	72.62	16	65.71	5	85.11	9	83.33
- Continuous change in governmental rules and regulations.	20	59.68	31	39.85	7	77.38	20	60.00	10	76.19	13	78.57
- Weather	28	55.87	16	54.89	23	65.48	21	60.00	30	38.10	31	45.24
- Inflation	31	51.75	29	42.86	29	59.52	15	65.17	29	42.86	27	57.14

Table 28 : Factors Importance Index for Freq. Of Rep. (cont'd.)

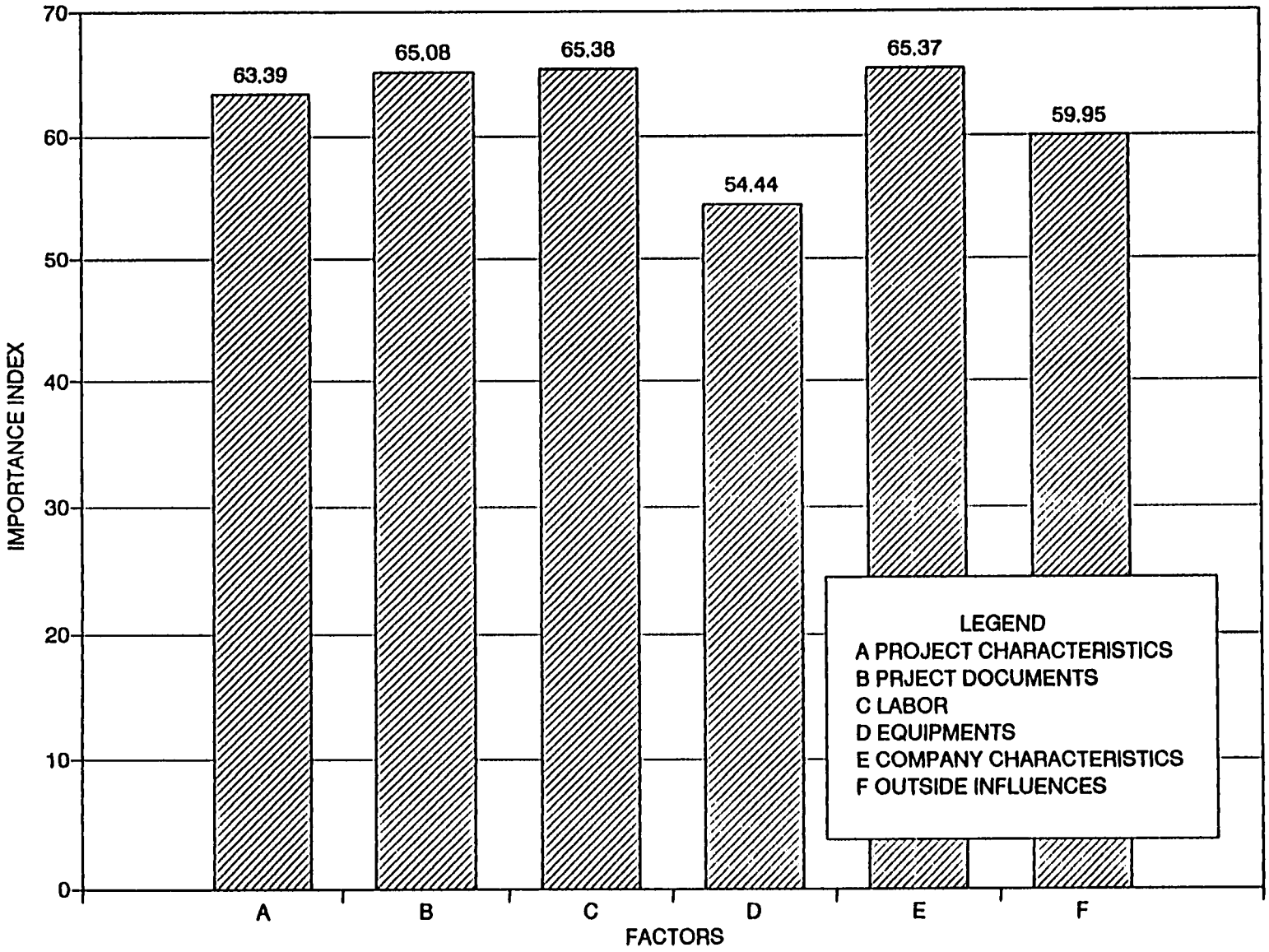


Fig. 32 : Freq. of Rep. Importance Index for all Grades (Broad Categories).

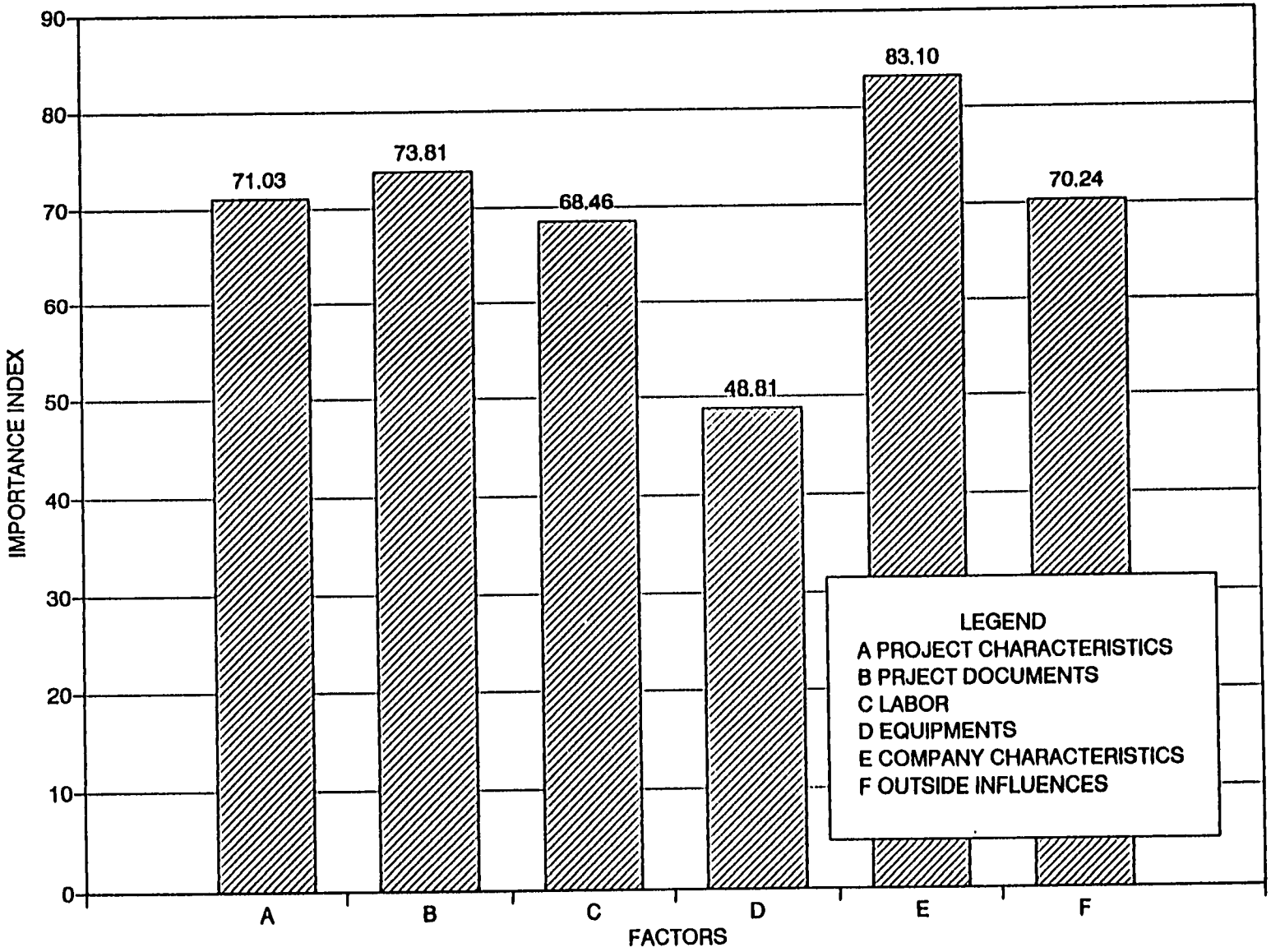


Fig. 33 : Freq. of Rep. Importance Index for Grade#1 (Broad Categories).

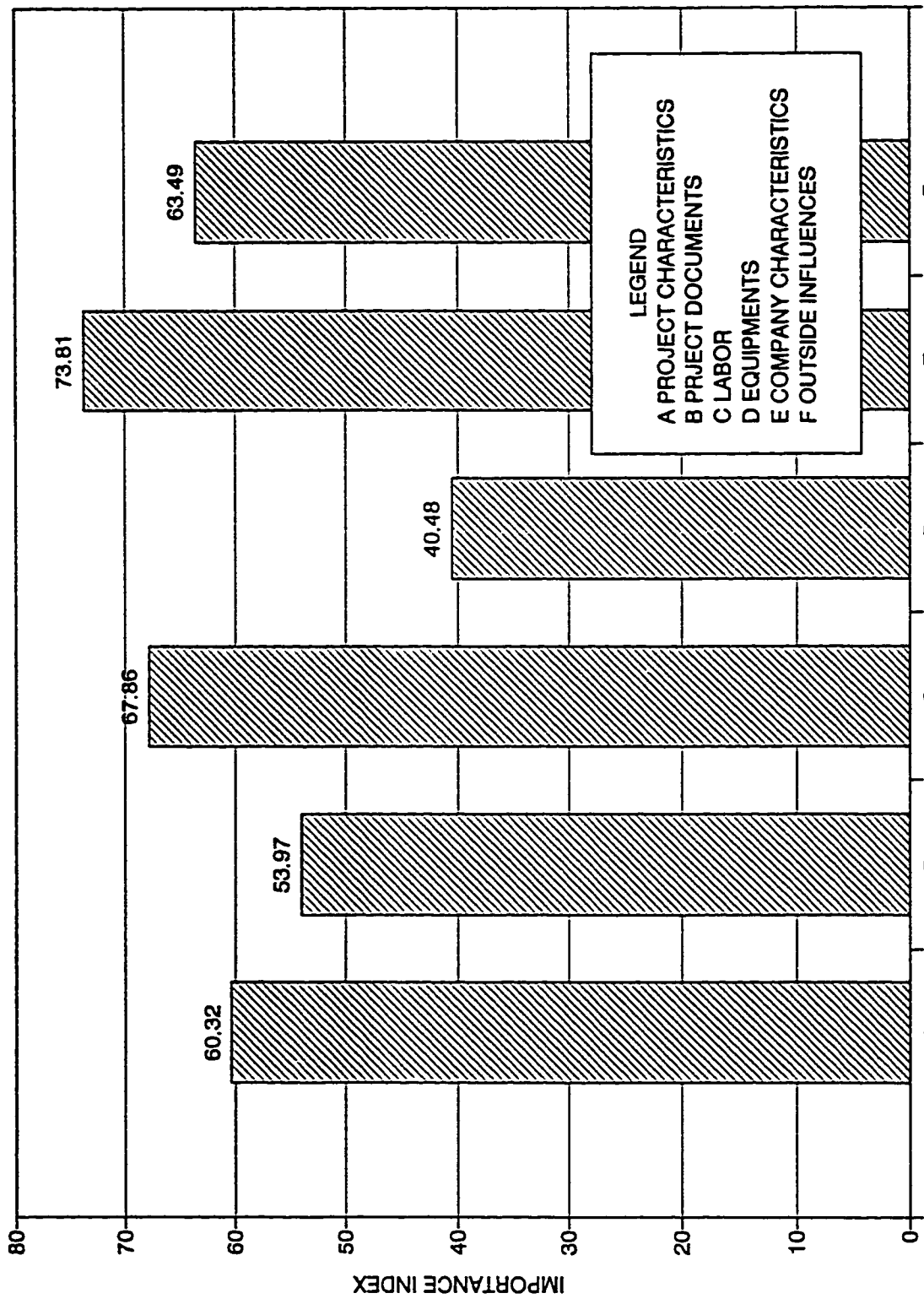


Fig. 34 : Freq. of Rep. Importance Index for Grade#2 (Broad Categories).

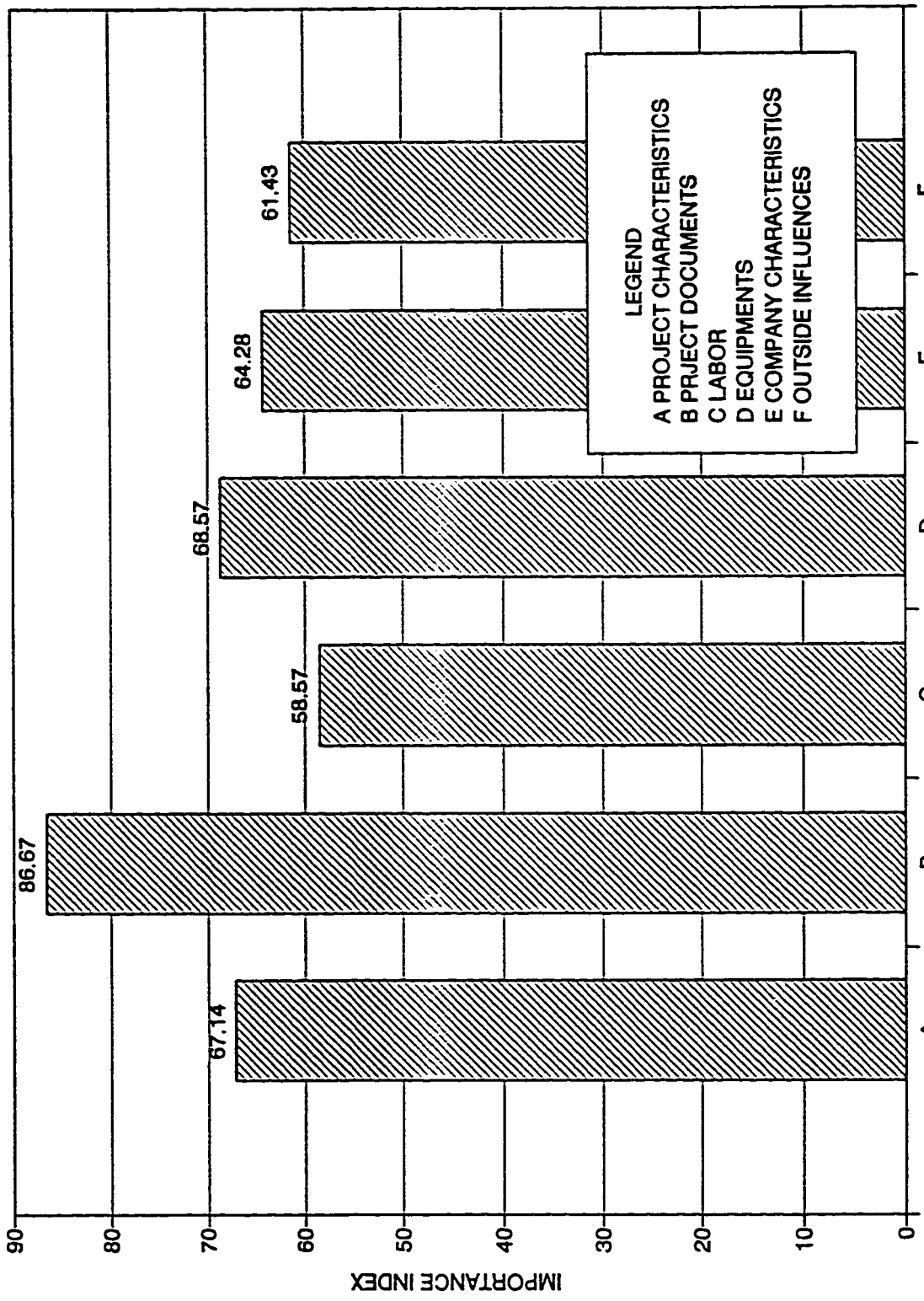


Fig. 35 : Freq. of Rep. Importance Index for Grade#3 (Broad Categories).

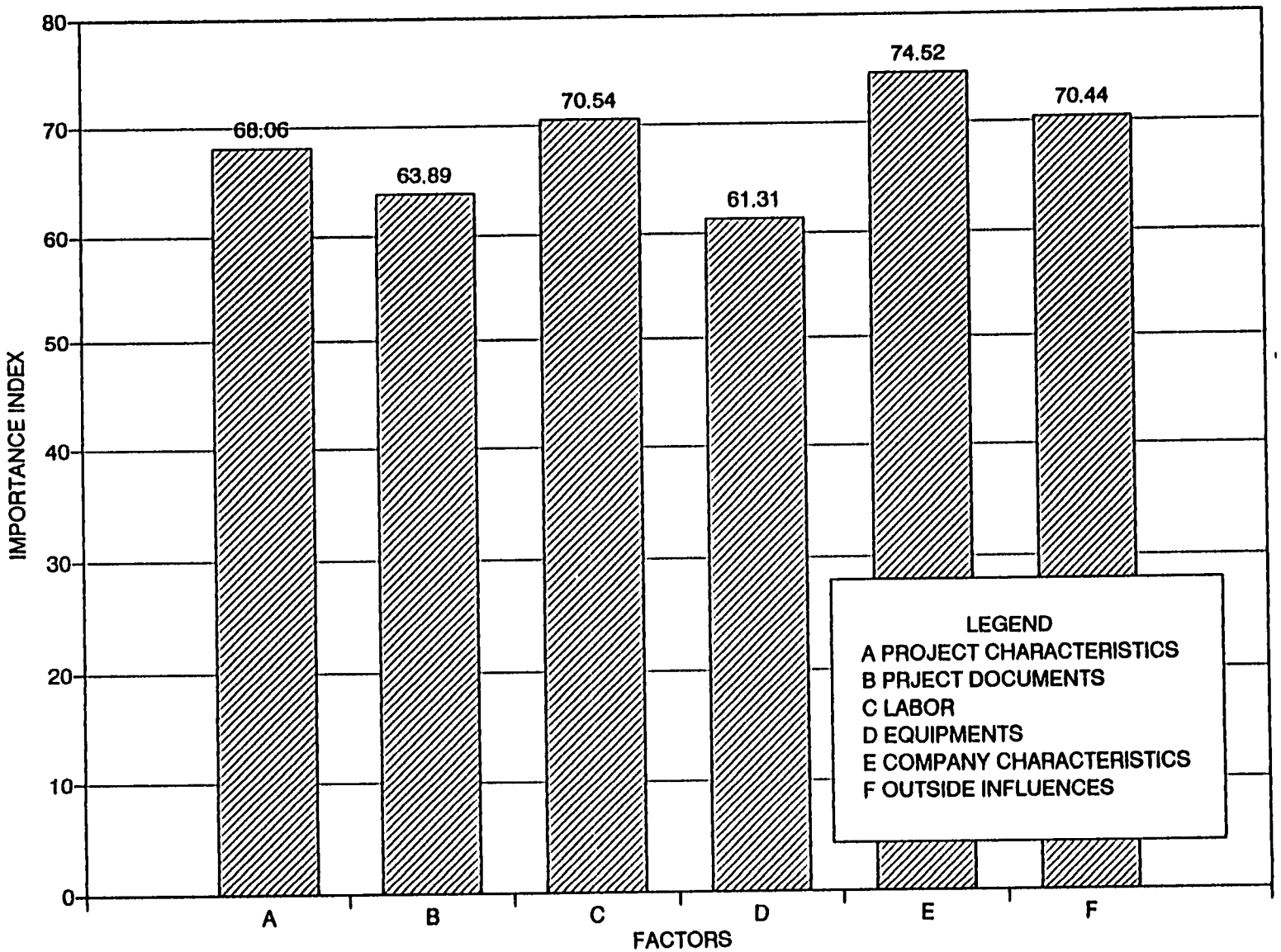


Fig. 36 : Freq. of Rep. Imprtance Index for Grade#4 (Broad Categories).

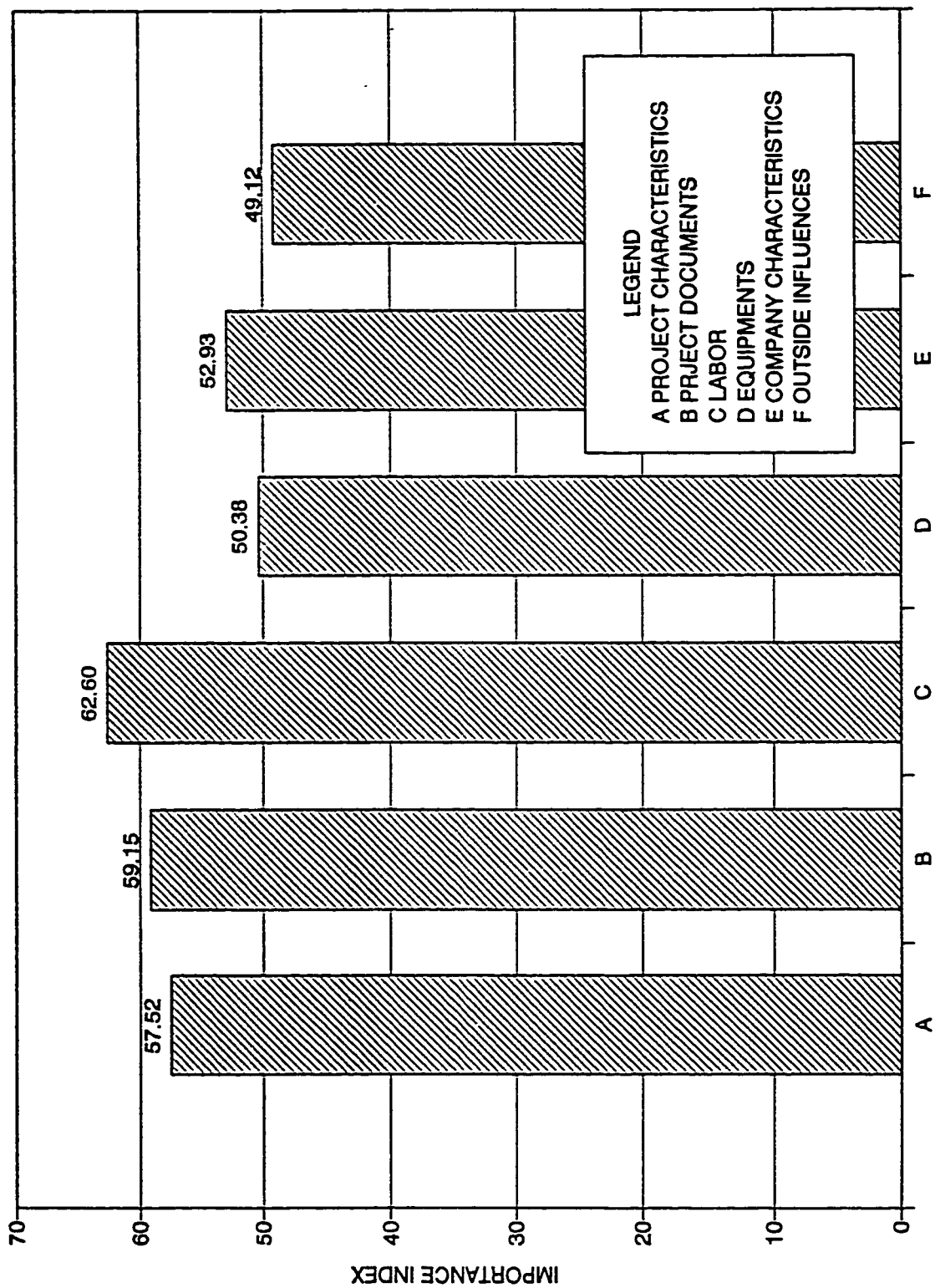


Fig. 37 : Freq. of Rep. Importance Index for Grade#5 (Broad Categories).

Table 29 summarizes the results of the Discriminant Analysis. From this figure the following can be observed:

1) Canonical Correlation for Function 1 = 0.945
2) Canonical Correlation for Function 2 = 0.858
3) Canonical Correlation for Function 3 = 0.766
4) Canonical Correlation for Function 4 = 0.694

From the above, the degree of association between the five grades and (CAN1, CAN2, CAN3 & CAN4) is very high, which suggests that the use of contractors' grades is a good discriminator.

By examining the Eigen value:

* Eigen value for Function 1 = 8.371
* Eigen value for Function 2 = 2.783
* Eigen value for Function 3 = 1.418
* Eigen value for Function 4 = 0.928

The above Eigen values show Functions 1 & 2 as the most powerful discriminators. Function 1 contributes to 62.01% of the discrimination while Function 2 contributes to 20.61%

5) Square Canonical Correlation for Function 1 = 0.893
6) Square Canonical Correlation for Function 2 = 0.736
7) Square Canonical Correlation for Function 3 = 0.586
8) Square Canonical Correlation for Function 4 = 0.481

CANONICAL DISCRIMINANT ANALYSIS

45 OBSERVATIONS 44 DF TOTAL
31 VARIABLES 40 DF WITHIN CLASSES
5 CLASSES 4 DF BETWEEN CLASSES

	CANONICAL CORRELATION	ADJUSTED CANONICAL CORRELATION	APPROX STANDARD ERROR	SQUARED CANONICAL CORRELATION	EIGENVALUE	EIGENVALUES OF INV(E)*H = CANRSQ/(1-CANRSQ) DIFFERENCE	PROPORTION
1	0.945140	0.901826	0.016087	0.893290	8.3712	5.5882	0.6201
2	0.857706	0.744420	0.039851	0.735660	2.7830	1.3650	0.2061
3	0.765708	0.583393	0.062348	0.586431	1.4180	0.4096	0.1050
4	0.693049	0.511455	0.078178	0.480426	0.9284	.	0.0688

TESTS OF H0: THE CANONICAL CORRELATION IN THE CURRENT ROW AND ALL THAT FOLLOW ARE ZERO

	LIKELIHOOD RATIO	APPROX F	NUM DF	DEN DF	PR > F
1	0.00604960	0.8932	124	42.3964	0.6888
2	0.05669191	0.6045	90	33.808	0.9696
3	0.21446594	0.4797	58	24	0.9882
4	0.51857356	0.4310	28	13	0.9697

MULTIVARIATE TEST STATISTICS AND F APPROXIMATIONS
S=4 M=13 N=4

STATISTIC	VALUE	F	NUM DF	DEN DF	PR > F
WILKS' LAMBDA	0.006049599	0.893	124	42.3964	0.6888
PILLAI'S TRACE	2.696807	0.868	124	52	0.7397
HOTELLING-LAWLEY TRACE	13.50054	0.925	124	34	0.6316
ROY'S GREATEST ROOT	8.371185	3.510	31	13	0.0098

NOTE: F STATISTIC FOR ROY'S GREATEST ROOT IS AN UPPER BOUND

Table 29 : Canonical Discriminant Analysis for Freq. of Rep.

From the above illustrated Square Canonical correlations, it can be verified that the proportion of variation in the discriminant functions is explained by the groups, especially for the first two functions.

9) Wilk's Lambda = 0.006

From this very small value, it can be shown that the high discrimination between the groups is not due to sampling (41). This high degree of discrimination can be visualized by allocating the centroid of the two functions (Fig. 38).

To study the most powerful discriminating factors, the previously mentioned two methods are used:-

1) TOTAL CANONICAL STRUCTURE:

Table 30 illustrates the total canonical structure for functions 1 and 2. For (CAN1) the most discriminating factors are: Size of Project, Tight Project Schedule, Size of Company, Unfamiliarity with Some Construction Process, Use of Computers, Timing of Resources Procurement, Poor Technical and Administrative Performance, Workload, Type of Approach to Project Management, Continuous Change Orders, Continuous Change in Government Rules and Regulations, and Claims.

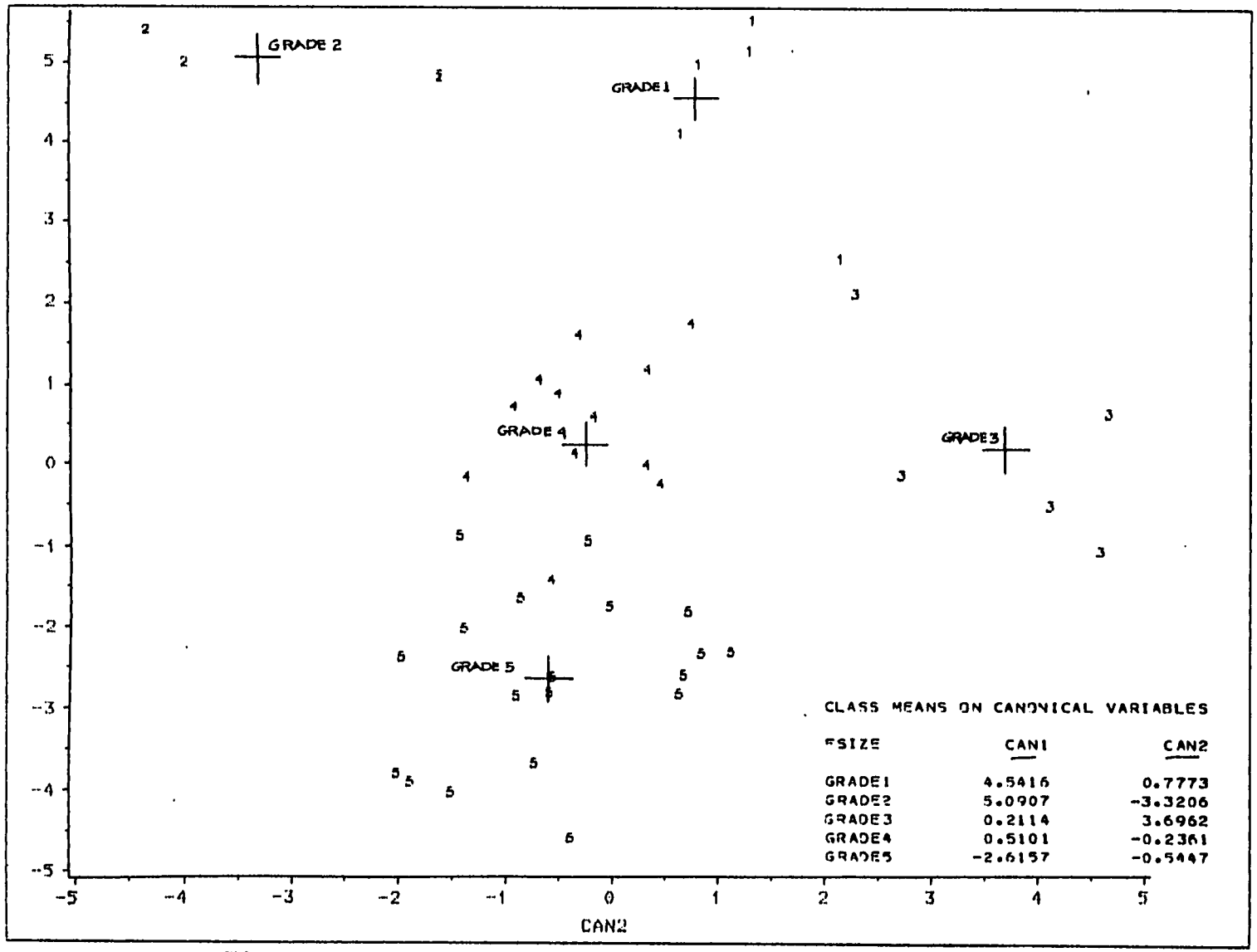


Figure 38 : Plot of (CAN1 & CAN2) for Freq. of Rep.

CANONICAL DISCRIMINANT ANALYSIS

TOTAL CANONICAL STRUCTURE

	CAN1	CAN2	CAN3	CAN4
FREQ1	0.3433	0.3549	0.1190	0.0157
FREQ2	-0.0015	0.0429	0.2996	0.1299
FREQ3	0.3859	0.1157	0.1443	-0.0187
FREQ4	0.0463	-0.0014	-0.1964	-0.1432
FREQ5	-0.0191	0.0802	0.0804	-0.0836
FREQ6	0.1433	0.0350	0.2898	0.0234
FREQ7	-0.0517	0.3785	0.0397	0.0012
FREQ8	0.2688	0.3164	-0.0272	0.0910
FREQ9	0.1556	0.3778	-0.0691	-0.0122
FREQ10	0.0414	-0.1489	0.1067	0.0639
FREQ11	0.1107	-0.1934	0.1436	-0.1174
FREQ12	0.0293	-0.0917	0.0799	-0.0492
FREQ13	0.1374	0.1760	0.1739	0.0297
FREQ14	0.1028	0.1801	0.1558	0.2119
FREQ15	-0.1739	0.2655	0.2043	0.1002
FREQ16	0.4787	-0.1031	0.1688	0.0366
FREQ17	0.3410	0.1883	0.1274	0.0084
FREQ18	0.5570	0.1293	0.0789	-0.0887
FREQ19	0.4357	0.0232	0.0589	0.0478
FREQ20	0.4016	0.0233	0.2334	0.0855
FREQ21	0.0704	-0.1518	0.3614	-0.1203
FREQ22	0.2494	-0.1138	0.1116	0.1837
FREQ23	0.3086	0.1945	0.2560	-0.3171
FREQ24	0.4623	-0.0424	0.4065	-0.0697
FREQ25	0.4072	0.2786	0.3429	0.0212
FREQ26	0.4918	0.0427	0.3518	0.1155
FREQ27	0.1334	0.2185	0.1750	0.0844
FREQ28	-0.1313	0.1044	0.2697	0.1158
FREQ29	0.2682	-0.0514	0.0084	-0.0247
FREQ30	0.5363	0.0522	0.1873	0.1110
FREQ31	0.2749	0.0003	0.4242	-0.1276

- Project Characteristics.
Freq1 = Size of project
Freq2 = Type of project
Freq3 = Tight project schedule
Freq4 = Complexity of Design
Freq5 = Quality Required
Freq6 = Project Location.

- Project Documents.
Freq7 = Contract clauses
Freq8 = Completeness of plans and specs.
Freq9 = Clarity of project objectives.

- Labor.
Freq10 = Poor labor productivity
Freq11 = Number of labor required/available
Freq12 = Skill of labor required/available
Freq13 = Labor relations problems.

- Equipment.
Freq14 = Number of equipment required/available
Freq15 = Type of equipment required/available

- Company Characteristics.
Freq16 = Size of company
Freq17 = Unfamiliarity with some construction process
Freq18 = Use of Technology (computers)
Freq19 = Timing of Resources Procurement
Freq20 = Poor technical and administrative performance
Freq21 = Reliability of budget estimate
Freq22 = Number of supervisors required/available
Freq23 = Work load (No. of projects available)
Freq24 = Type of approach to project management
Freq25 = Continuous change orders.

- Outside Influences.
Freq26 = Continuous change in government rules and regulations
Freq27 = Inflation
Freq28 = Weather
Freq29 = Unforeseen site conditions
Freq30 = Claims
Freq31 = Owner interference during construction

Table 30 : Total Canonical Structure for Freq. of Rep.

For (CAN2) the most discriminating factors are: Size of the Project, Contract Clauses, Completeness of Plans and Specifications and Clarity of Project Objectives. From these two functions, fifteen factors are considered the most powerful contributors to discrimination. From broad categories perspective, the following can be observed:

- 13.3% (2/15) of the factors that contribute to discrimination are related to Project Characteristics.

- 20.0% (3/15) of the factors that contribute to discrimination are related to Project Documents.

- 0.0% of the factors that contribute to discrimination are related to Labor.

- 0.0% of the factors that contribute to discrimination are related to Equipment.

- 53.3% (8/15) of the factors that contribute to discrimination are related to Company Characteristics.

- 13.3% (2/15) of the factors that contribute to discrimination are related to Outside Influences.

2) STANDARDIZED CANONICAL COEFFICIENTS:

In this method, no factors having a high discrimination power are observed (Table 31).

A very important point to be noticed is that factors related to company characteristics are the most significant contributors to discrimination. These discriminating factors are explained as follows:

A) SIZE OF COMPANY:

The larger the company, the more frequently reports are needed. Big contractors involve different levels of management. Normally, upper management levels are only concerned with summary status reports. More detailed and frequent reports are needed for lower levels of project personnel. On the other hand, since small contractors have a very limited number of personnel, the management are more exposed to the construction site and therefore fewers status reports are needed.

B) UNFAMILIARITY WITH SOME CONSTRUCTION PROCESS:

Unfamiliarity with some construction process forces project personnel to produce more frequent reports regarding project status, so any unexpected deficiency is spotted.

CANONICAL DISCRIMINANT ANALYSIS

STANDARDIZED CANONICAL COEFFICIENTS

	CAN1	CAN2	CAN3	CAN4
FREQ1	-0.3724	0.9033	-0.7984	-0.2392
FREQ2	0.5273	-0.7249	1.2836	0.6146
FREQ3	0.3747	-0.6566	-0.0530	0.6041
FREQ4	0.6039	-0.4222	-1.7351	-0.6785
FREQ5	-1.7687	0.3122	-0.7060	-0.7199
FREQ6	1.2079	-0.0307	0.8978	0.2712
FREQ7	-1.2490	1.0016	-0.0619	-0.9125
FREQ8	0.6439	0.1499	0.5003	0.9922
FREQ9	0.6997	0.7514	0.2882	-0.0420
FREQ10	0.5357	-0.6703	1.4247	0.8636
FREQ11	-1.5891	-0.5069	-1.6504	-2.8058
FREQ12	1.7115	0.5854	-0.2698	0.9248
FREQ13	-0.4463	-0.1465	-0.9327	-0.1433
FREQ14	0.5957	0.5136	0.6232	1.6489
FREQ15	-0.5643	0.4035	-1.1012	-0.1027
FREQ16	0.8390	-0.3806	-0.6994	-0.4686
FREQ17	-1.1717	0.4492	1.4912	0.0387
FREQ18	1.5382	0.2872	0.3202	-0.1045
FREQ19	0.1665	-0.7636	0.4065	0.2957
FREQ20	0.1655	-1.5226	-1.6743	-0.3520
FREQ21	-0.5181	-0.8427	2.0301	0.5499
FREQ22	-1.2968	0.1002	0.5226	0.9272
FREQ23	0.5195	-0.0725	1.1190	-0.5763
FREQ24	-0.0850	0.1853	-0.0736	-0.6195
FREQ25	-0.3165	0.6298	0.4786	-0.9033
FREQ26	1.4732	-0.1305	0.1694	0.2370
FREQ27	0.4436	1.0773	-0.7567	-0.2707
FREQ28	-1.3234	-0.2715	0.4333	-0.0201
FREQ29	1.3141	0.0662	-0.7014	-0.1101
FREQ30	0.4362	0.2264	-0.9310	0.6067
FREQ31	0.7196	0.8889	0.6629	0.2526

- Project Characteristics.
Freq1 = Size of project
Freq2 = Type of project
Freq3 = Tight project schedule
Freq4 = Complexity of Design
Freq5 = Quality Required
Freq6 = Project Location.

- Project Documents.
Freq7 = Contract clauses
Freq8 = Completeness of plans and specs.
Freq9 = Clarity of project objectives.

- Labor.
Freq10 = Poor labor productivity
Freq11 = Number of labor required/available
Freq12 = Skill of labor required/available
Freq13 = Labor relations problems.

- Equipment.
Freq14 = Number of equipment required/available
Freq15 = Type of equipment required/available

- Company Characteristics.
Freq16 = Size of company
Freq17 = Unfamiliarity with some construction process
Freq18 = Use of Technology (computers)
Freq19 = Timing of Resources Procurement
Freq20 = Poor technical and administrative performance
Freq21 = Reliability of budget estimate
Freq22 = Number of supervisors required/available
Freq23 = Work load (No. of projects available)
Freq24 = Type of approach to project management
Freq25 = Continuous change orders.

- Outside Influences.
Freq26 = Continuous change in government rules and regulations
Freq27 = Inflation
Freq28 = Weather
Freq29 = Unforeseen site conditions
Freq30 = Claims
Freq31 = Owner interference during construction

Table 31 : Standardized Canonical Coefficients For Freq. of Rep.

These frequent reports arise from the willingness of the project management to depict the progress of the project when using some construction process that has never been used before.

C) USE OF TECHNOLOGY:

The use of computers is considered one of the most important contributors in the field of project reporting, so any number of reports can be cheaply produced at any time required. However, since computers cannot be afforded by small contractor, computers are most effective in the big companies.

D) TIMING OF RESOURCES PROCUREMENT:

It was previously stated that the problem of timing of resources procurement was handled by big contractors by assigning specialized personnel. However, project status reports are the means of communication among these personnel. As a result, more frequent reports are produced by big contractors than small ones to cope with procurement problems.

E) POOR TECHNICAL AND ADMINISTRATIVE PERFORMANCE:

Poor technical and administrative performance forces contractors to produce more detailed and frequent reports to investigate performance deficiencies. As was previously found, big contractors depend on different types of project status reports to measure and evaluate performance. On the other hand, less frequent and very simple formats of reports are used by small contractors.

F) WORKLOAD:

The number of projects available usually influences the number of project reports in two ways: (1) due to the time spent in collecting and analyzing site data, the smallest practical number of reports should be produced. (2) The reports should be frequent enough to avoid any un-expected problem. Because of the big size of projects handled by first, second and third grade contractors, they usually produce more frequent reports than small contractors

G) TYPE OF APPROACH TO PROJECT MANAGEMENT:

As a result of the different approaches in project management practice, reporting periods differ from one contractor to another. However, as sophisticated techniques are used by the lower grade number contractors, more frequent reports are needed.

H) CONTINUOUS CHANGE ORDERS:

Continuous change orders are directly related to the frequency of reporting. Whenever a site change is required, it should be reflected in the project status reports. In addition, it may be necessary to increase the frequency of reporting or even to produce special reports to reflect the effects of such changes.

The impact of Project Characteristics can be highlighted as follows:

A) SIZE OF PROJECT:

When the size of the project gets bigger, more activities are required. This situation creates a need to produce more frequent reports of project status to control the cost of execution. So the lower the contractor's grade number, the more frequently reports are needed.

B) TIGHT PROJECT SCHEDULE:

When the project schedule gets tight, more frequent reports are needed to guarantee the work is proceeding as scheduled. This need arises from the fact that, if any schedule slippage is discovered during project execution -specially near the end of the project- the project manager will either suffer from delay penalty or have to consume more resources to comply with the schedule. Both of these situations may expose the project to budget overrun.

The effect of Project Documents can be explained as follows:

A) CONTRACT CLAUSES:

The types of clauses incorporated in the contract help in deciding on how frequent the project reports should be. As an example, tough penalties may force the contractor to produce more frequent reports to avoid any cost hazard.

B) CLARITY OF PROJECT OBJECTIVES:

Usually when the project objectives are unclear, more frequent reports may be needed to avoid any unforeseen project conditions. This phenomenon is experienced particularly by the contractors of high grade numbers who usually suffer from unclear project objectives.

C) COMPLETENESS OF PLANS AND SPECIFICATIONS:

If the project documents are not complete, more frequent reports may be needed to avoid the cost hazards resulting from any missing information.

The effect of Outside Influences can be explained as follows:

A) CLAIMS:

Projects exposed or expected to be exposed to claims should be supported with more frequent reports. These reports help to increase awareness regarding project status as well as to provide a document showing the actual progress of the work.

B) CONTINUOUS CHANGE IN GOVERNMENT RULES AND REGULATIONS:

If the project is located in an area which suffers from continuous change in governmental rules and regulations, more frequent reports are usually produced to reflect the the effect(s) of such changes on project cost.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 STUDY SUMMARY:

Controlling the cost of the project construction is considered one of the major and most important concerns for any contractor. Due to such importance, this study is directed towards investigating the current construction cost control practice among the building construction contractors in the Eastern Province of Saudi Arabia.

A series of structured interviews was conducted with forty-five randomly selected contractors. These interviews were directed towards exploring the tools used by the contractors to control the construction cost, reason(s) for using each tool, their advantages, disadvantages and degree of effectiveness. Cost control yardstick, measuring actual cost, reporting system, cost variance analysis and site corrective actions were studied and reported. In addition, this study investigates the factors that affect the level of control exerted during construction. The level of control was represented by three parameters; degree of work breakdown structure, degree of organization breakdown structure and frequency of reporting.

Data obtained from this study were post-stratified according to the five contractors grades specified by the Ministry of Public Works and Housing (Agency of Classification of Contractors) in Riyadh.

5.2 MAJOR FINDINGS AND CONCLUSIONS:

5.2.1 Methods of Construction Cost Control:

The results of this research indicate the contractors follow a basic logic sequence in cost control. However, the following can be noticed:

A) BUDGET SETTING:

1) Most of the small contractors depend on very general and simple procedure in project estimation, without studying all necessary details. This, in most cases, results in a shortage of cash flow during construction, which in turn may result in cutting corners. On the other hand, the contractors who have their head offices outside the Kingdom do their project study and cost estimation abroad. The main drawback of this method is that they base their cost estimates on un-realistic assumptions, which in turn may have undesirable effects.

2) During the interviews, it was found the main source for site analysis is the soil report, which forms the basis for estimation in most cases.

3) For most of the contractors, the method of work breakdown structure is based on standard item headings predefined at head office. Regardless of the justification behind this choice, an effective work breakdown structure should reflect the actual site conditions. These conditions in effect aid in determining the appropriate level of W.B.S. details. This level of details will in turn form the basis for determining the most economical and practical number of cost codes.

4) For most of the contractors, the concept of codes of accounts does not appear to be familiar, except for some big or foreign companies.

5) During construction, estimator price formed the main basis for budgeting. The lack of true site analysis before the start of a new phase of work or work item is noticed.

6) A period between 1-4 weeks was noticed to be the most commonly used period for short term planning. However, according to a study conducted in Australia a period of 1 week in most cases is considered to be practical (14). During this period, enough work is done to be analyzed, keeping

in mind that building construction is characterized by short duration for each work item.

B) MEASURING ACTUAL COST:

7) Personnel observations were noticed to play an important role in charging resource hours - specially for labor - during construction. On the other hand, less importance was given to charging equipment hours. The main reason for this is the high percentage of lease or rent among the contractors which shifted their concentration towards labor rather than equipment. In addition, it should be remembered that building construction is a labor-intensive profession with limited need for construction equipment.

8) Material charging during construction was noticed to be highly dependent on purchase orders and invoices. However, since these tools do not show exactly how much is consumed, it can be concluded that they are mainly made to satisfy the head office.

9) Using All-in Rates was not given the importance it deserves as a new method for project costing (for more information about this method refer to Reference 7). However, the applicability of this method to Saudi Arabia cannot be judged until it is tried.

C) REPORTING ACTUAL COST:-

10) The lack of systematic and established procedure for feedback from site to head office is a prime finding. The phenomenon is clearer in contractors of higher grade numbers where subjectivity plays an important role. In comparison, contractors of lower grade numbers are too involved in paper work. This practice shifted the site engineers' attention from controlling the cost to filling-out the extensive reporting forms to satisfy the head office.

11) Monthly cost statements were found to be the most dominant period for cost and status reporting. Since one month is too long to detect any deviation before it becomes serious, the use of this method suggests that the main value of these reports is to coincide with wages and governmental payments.

12) The main trend which was noticed among the contractors is the efforts made to enhance cash flow during construction. In this trend, the contractors normally report the completion of more work than was actually done to obtain the owners' progress payments for each work phase, and in turn not to report the real construction costs exactly.

D) COST VARIANCE TESTING:-

13) Budgeted vs. actual cost of work done to date was found to be the most common cost status evaluation technique. However, this method neglects the actual value of work done to date. This value is mainly determined by comparing the scheduled vs. the actual cost and schedule of work accomplished to date (14). As a result of using this technique, estimator pricing formed the main source of performance evaluation.

E) CAUSES OF HIGH COSTS AND CORRECTIVE ACTIONS:

14) Informal - tried and true - methods for investigating cost discrepancy is widely spread among contractors. In addition, work study is not used among most of the contractors either to investigate cost discrepancy or to decide on the appropriate corrective action. Even the small number of contractors who utilize this method do not utilize it fully and it is applied in a very simple form (for more information regarding this method refer to reference 5).

15) The dependence on incentives as a site corrective action is most dominant. This method, which depends on productivity improvement, lacks a systematic and established procedure for application, and subjectivity plays an important role in actions taken at the site level.

5.2.2 Factors Affecting the Level of Control:

1) In deciding on the degree of work breakdown structure for construction cost control, Company Characteristics, Project Characteristics and Project Documents are considered the most decisive factors. Within these broad categories, Tight Project Schedule and Timing of Resources Procurement are considered the most important.

2) Organization breakdown structure is mostly affected by Project Characteristics, Company Characteristics, Labor and Project Documents. Within these categories, Tight Project Schedule, Size of Project and Size of Company are considered the most influential factors.

3) In deciding on the frequency of reporting, Labor, Company Characteristics, Project Documents and Project Characteristics are considered the most important factors. Within these broad categories, Tight Project Schedule is the most important factor.

4) Company Characteristics, Project Characteristics and Project Documents are the common denominators among work breakdown structure, organization breakdown structure and frequency of reporting. These categories form the common factors in deciding on the level of control.

5) In grouping the contractors according to the five grades, Company Characteristics forms the most important discriminator for work breakdown structure.

6) In the organization breakdown structure, Company Characteristics is the most important discriminator among the five contractors grades.

7) Among the five contractor grades, Company Characteristics is also considered the most important discriminator for the frequency of reporting.

8) Company Characteristics has a noticeable effect in discriminating among the five grades of contractors when deciding on the level of control. This finding seems consistent with the basis for classifying the contractors according to the contractors grades specified by the agency of classifying the contractors in Riyadh.

5.3 RECOMMENDATIONS: -

From the previous discussions, and in order to enhance the current situation, the following are recommended .

* The use of realistic cost estimates based on "work study" outputs and performance records from previous projects.

* Maximizing the range of applicability of cost and performance data by means of cost and performance data standardization. Such standardization, which is necessary for measuring productivity and site budgeting, can be achieved by the following steps:-

  1. Record and transmit field productivity data.

  2. Assess the reliability of the data and assign it to its appropriate classification.

  3. Calculate the standard times, outputs at standard performance and standard costs from "raw" data.

  4. Store the standards in a "data bank", which is composed of historical and current information.

  5. Determine company policy allowances and in-house management efficiency.

6. Determine job management and local site conditions for the project in hand.

7. Estimate most likely productivities and costs, including their possible range of variation. This is achieved by the factoring of output at a standard performance appropriate to arrive at the expected productivity for the work concerned at the project location. As an example, these adjustment factors may range from 0.85 for excellent management and job site to 0.50 for poor management and job site. (14)

* Avoid excessive detailing of work breakdown structure, which may introduce high overhead, more paper work and difficulty in updating work progress.

* Use All-in Rates approach, at least experimentally, to determine its effectiveness when applied in Saudi Arabia. These experiments can be made with the aid of the Ministry of Public Works and Housing.

* Adopt formal work study programs to enhance work productivity based on random activity sampling. This work study is to be integrated with human judgement for maximum benefit.

* Introduce project personnel to new construction and project controlling techniques by formal study programs and specialized publication. This will assess in enhancing their background in construction practices.

* Since Company Characteristics is the most influential broad category on the level of control exerted during construction, the contractors are recommended to study this factor thoroughly when deciding on the appropriate level of control.

* In deciding on the level of work breakdown structure, Tight Project Schedule and Timing of Resources Procurement should be taken into consideration.

* To decide on the organization breakdown structure, Tight Project Schedule, Size of Project and Company Size should be well studied and evaluated.

* To decide on the frequency of producing project cost reports (frequency of reporting), Tight Project Schedule should be emphasized.

5.4 RECOMMENDATIONS FOR FUTURE STUDIES:

1. Form a research team to study the applicability of the new techniques and tools to control construction costs in Saudi Arabia. Such techniques include the following:

   a) Using All-in-Rates approach for data standardization and resource costing.

   b) Applying work study techniques in analyzing cost deviations.

2. Survey the software available in the market that help in project cost analysis and reporting.
3. The same research could be done again by a group of researchers. Each researcher would conduct the interviews with just a few contractors. This technique would help to achieve a more informative research.

4. Comparative studies can be extended to investigate cost control practice among the major contractor types, building, engineering and industrial.

5. Further studies can be conducted to determine the effect of cost control over project quality.

APPENDIX A
INTERVIEW QUESTIONS
(ENGLISH & ARABIC)

INTERVIEW QUESTIONS

COMPANY NAME :

TITLE OF RESPONDENT:

COMPANY ADDRESS :

(I) QUESTIONS ABOUT CONTRACTOR FIRM

Please circle the statement(s) that describe(s) your firm.

1) Type of Contractor

   a) Building (Educational, Commercial...etc.)

   b) Engineering (Highway,...etc.)

   c) Industrial (Power Plants, Refineries,...etc.)

   d) Others (specify)...

2) Number of Perminent Employees (including Trade and Foremen).

   a) Under 100 b) 100-299 c) 300-499

   d) 500-699 e) Over 699

3) Value of construction equipment owned (millions of S.R.):

   a) Under 1 b) 1-Under 10 c) 10-Under 20

   d) 20-Under 30 e) 30-Under 40 f) 40 or over

4) Percent of Equipment leased or Rented:

   a) None b) Less than 25%

   c) 25%-Under 50% d) 50%-Under 75%

   e) 75-100%

5) Maximum Job size (millions of SR)

a) under or equal to 5 b) over 5-15

c) over 15-50 d) over 50-200

e) over 200

6) Average job duration (years):

a) under 1/2 b) 1/2-Under 1 c) 1-Under 2

d) 2-Under 3 e) 3-Under 5 f) 5 or over

7) Number of area/branch offices (site offices)

a) None b) 1 c) 2

d) 3 e) 4 f) 5

g) Other (specify)_____

8) Number of area/branch offices (not including site offices)

a) None b) 1 c) 2

d) 3 e) 4 f) 5

g) Other (specify)_____

9) What is the percentage of work that is awarded through competetive bidding:

a) Less than 20 b) 20-Under 40 c) 40-Under 60

d) 60-Under 80 e) 80-100

10) What is the percentage of work that is obtained as a lumpsum contract:

a) 0-Under 20 b) 20-Under 40 c) 40-Under 60

d) 60-Under 80 e) 80-100

II - QUESTIONS REGARDING COST CONTROL PROCEDURES

Circle the answer(s) that best describes your firm. You may circle more than one answer. The degree of effectiveness in the questions is related to how effective each method to achieve the attached list of criteria, where:

1 = Not effective

7 = Very effective

1) What is the percentage of subcontracted work in a given project:-

a) 0-under 20 b) 20-under 40

c) 40-under 60 d) 60-under 80

e) 80-100

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

2) The method for work/breakdown structure for site use depends on:-

a) Standard item headings predefined at head office (main or total resources for each trade package, like all brick work).

b) Work item headings specially tailored to project work breakdown structure.

c) Division of work into major structural components and locations.

d) Division of work according to main resources categories per period (ie: plant, material...etc.).

e) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

3) How many cost codes are utilized during construction (Alpha-numaric labels that relate work breakdown structure and organization breakdown structure with financial information:-

a) 1-15 b) 16-30 c) 31-45

d) 46-60 e) > 60 f) None

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

4) Budgeting for site use depends on:-

a) Direct use of estimator pricing

b) Use of historical record site data

c) Analysis of site conditions and subsequent budgetary adjustments.

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

5) During construction, what is the period for short term planning and control:

a) 1 week b) 2-4 weeks

c) 5-6 weeks d) > 6 weeks

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

6) Which is (are) utilized for site planning and control:-

a) Weekly site meetings to discuss problems

b) Weekly job cards for each work crew that specify the next week work target.

c) Bar charts (specify target and actual progress)

d) Monthly site meetings

e) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

7) When comparing actual vs. desired level of performance which of the following is (are) utilized as performance yardstick:-

a) Budgeted vs. actual cost of work done to date.

b) Budgeted vs. forcasted actual total cost at completion.

c) Budgeted vs. actual unit costs.

d) Budgeted vs. actual cost of each trade package.

e) This period unit cost vs. current comulative unit cost to last period.

f) Scheduled vs. actual cost, quantity and schedule of work completed (achieved value method).

g) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

8) Data used for comparing actual vs. desired level of performance are derived from:

a) Estimator pricing

b) Feed back records (past records of site data)

c) Site analysis

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

9) What is (are) the frequency of measuring actual performance during construction (Frequency of cost statements):-

a) Daily b) Weekly c) Monthly

d) Quarterly e) Others_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

10) In costing the resources during construction, labor hours are allocated by:-

a) Personal observations

b) Record of manhours consumed for each work item

c) Time books

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

11) Plant (Equipment) hours are allocated by:-

a) Summary of Equipment hire invoices.

b) Daily record of equipment operating hours for each work item.

c) Timesheets of equipment operators

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

12) Material consumed for construction is allocated by:

a) Purchase orders

b) Invoices

c) Field quantity reports for each work item

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

13) Resources cost is calculated by:-

a) All in rates: Labor and equipment total cost per hour are calculated by the estimator at the date of tendering for pricing and kept constant.

b) Actual paid cost per hour.

c) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

14) In converting manhours to monetary items, which of the following is (are) utilized:-

a) Labor rate: basic wage + on costs

b) Labor rate: just the basic wage while others are treated as overhead.

c) Others_____

_____

Advantage:_____

Disadvantage:_____

15) In converting Plant Hours to monetary items, which of the folliwing is (are) utilized:-

a) Plant rate: ownership + operating cost

b) Plant rate: Just ownership cost while operating cost is treated as overhead.

c) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

16) In case of any cost and/or schedule deviation, which of the folloiwng is (are) utilized for investigating cost discrepancy:-

a) Informal investigation

b) Inference/Logic

c) Intuition/Gut feeling

d) Work study (a systematic examination of activities-in order to improve the effective use of human and other resources-based on random activity sampling.

e) Periodical supervisory meetings_____

f) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

17) In case of any cost discrepancy, variance is calculated by:-

a) Absolute numbers

b) Percent of parent budget of work under consideration.

c) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

18) In the case of any cost discrepancy which of the following is (are) used as site corrective action:-

a) Incentive schemes

b) Work study technique

c) Spot costing: disclosing the specific problem in a work item by costing the component operations within that item on a very detailed basis.

d) Job card: A weekly record of the work content and time required for job tasks for each work crew.

e) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

19) Computerization of cost control procedures are in the form of:

a) Centralized system in the head office

b) On site level computers

c) Computers are not used

d) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

* In case of any work is subcontracted:-

20) To monitor the quantity of work done and material used which of the following is (are) utilized:

a) Joint progressive measure (for the contractor and subcontractor)

b) Subcontractor status reports

c) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

21) To record all services and attendance cost, the following is (are) utilized:-

a) Subcontractor status reports

b) Forman's record

c) Others_____

_____

Advantage:_____

Disadvantage:_____

Circle the Degree of effectiveness: 1 2 3 4 5 6 7

III - QUESTIONS ABOUT THE FACTORS THAT AFFECT THE LEVEL OF CONTROL

From your construction Experience in your company, please indicate the impact level the following factors have on:

a) Frequency of reporting (Freq. of Rep.)

b) Degree of work break down structure (W.B.S.)

c) Degree of organization break down structure(Org.B.S.)

Use a scale from 1-7 where

1= Don't have an effect (Low effect)

7= have a great effect (High effect)

		Freq.of Rep.		Deg.of W.B.S.		Deg.of Org:B.S.	
		L	H	L	H	L	H
A)	Project Characteristics:						
1.	Size of project (in millions of SR)	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	
2.	Type of project (Building,Eng...etc.)	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	
3.	Tight Project Schedule	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	
4.	Complexity of design	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	
5.	Quality required	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	
6.	Project location	1 2 3 4 5 6 7		1 2 3 4 5 6 7		1 2 3 4 5 6 7	

	Freq.of Rep.	Deg.of W.B.S.	Deg.of Org:B.S.
	L H	L H	L H
7. Others(Specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
B) Project Documents:			
8. Contract clauses (penalties, incentives.. etc.)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
9. Completeness of plans & specs.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
10. Clarity of project objectives	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
11. Others(specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

C) Labor:			
12. Poor labor productivity	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
13. Number of labor required/available	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
14. Skill of labor & required/available	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
15. Labor relations problems	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
16. Others (specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
D. Equipment:			
17. Number of equipment required/available	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
18. Type of equipment required/available.	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
19. Others (specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

	Freq.of Rep.	Deg.of W.B.S.	Deg.of Org:B.S.
	L H	L H	L H
E. Company Characteristics (The Contractor)			
20. Size of company	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
21. Unfamiliarity with some construction process	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
22. Use of technology (use of computers for site and head office)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
23. Timing of resources procurement	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
24. Poor technical and administrative performance	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
25. Reliability of budget estimate	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
26. Number of supervisors required/ available	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
27. Work load (No. of projects available)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
28. Type of approach to project management	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

	Freq.of Rep.	Deg.of W.B.S.	Deg.of Org:B.S.
	L H	L H	L H
29. Continuous change orders	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
30. Others (specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
F. Outside of Influences:			
31. Continuous change of government rules and regulations	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
32. Inflation	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
33. Weather	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
34. Unforeseen site conditions	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
35. Claims	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
36. Owner interference during construction	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
37. Others (specify)			
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
_____	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

* If you have any more comments that may help to add more feedback to this study please add below:

_____

_____

_____

_____

_____

Thank you for your cooperation.

Characteristics of an Effective Cost Control System:

Inspite of the subjectivity in selecting or developing a cost control system, an effective cost control system should possess the following characteristics:

- Provide good control during construction, by spotting cost trouble areas, aid to take corrective actions, and measure the effectiveness of the action taken.
- Simple where it is understood by low level people.
- Flexible in usage, where it allows ease of updating and fitting to the organization structure of the company concerned.
- Control schedule, where any slippage in project execution schedule would cost the contractor more, due to resource consumption and paid liquidated damages.
- Control Performance
  The control system should control the cost of construction while maintaining the specified level of performance for the project.
- Feedback provision: where data about project status as well as the resources involved are continuously reported.
- Provide Data for evaluation of variation:
  Where actual work is compared to the estimated.

استبيان

اسم الشركـــه :

المهنـــــه :

عنوان الشركـــه :

اولا :- اسئلة خاصة بشركة المقاول

الرجاء اختيار الاجابة التى تناسب شركتك (بالامكان اختيار اكثر من اجابة واحده) .

١ - نوع الشركه :

أ) مبانى (تعليميه ، تجاريه ... الخ)
ب) هندسيه (طرق - الخ .....)
ج) صناعيه (مصانع - الخ .....)
د) غيرها (حدد - .....)

٢ - عدد الموظفين الدائمين (يشمل العمال والمشرفين)

أ) اقل من ١٠٠
ب) ١٠٠ - ٢٩٩
ج) ٣٠٠ - ٤٩٩
د) ٥٠٠ - ٦٩٩
هـ) اكثر من ٧٠٠

٣ - قيمة اجهزة الانشاء الماليه المملوكه لدى الشركه (بالمليون)

أ) اقل من ١
ب) ١ - اقل من ١٠
ج) ١٠ - اقل من ٢٠
د) ٢٠ - اقل من ٣٠
هـ) ٣٠ - اقل من ٤٠
و) اكثر من ٤٠

٤ - نسبة الاجهزة المتاجرة على المدى القصير والبعيد

أ) لا يوجد
ب) اقل من ٢٥ ٪
جـ) ٢٥ ٪ اقل من ٥٠ ٪
د) ٥٠ ٪ اقل من ٧٥ ٪
هـ) ٧٥ ٪ اقل من ١٠٠ ٪

٥ - متوسط حجم المشاريع للشركة (بالمليون)

أ) اقل او يساوى ٥
ب) اكثر من ٥ - ١٥
جـ) اكثر من ١٥- ٥٠
د) اكثر من ٥٠- ٢٠٠
هـ) اكثر من ٢٠٠

٦ - متوسط مدة المشاريع بالسنين

أ) اقل من $\frac{1}{2}$
ب) $\frac{1}{2}$ - اقل من ١
جـ) ١ - اقل من ٢
د) ٢ - اقل من ٣
هـ) ٣ - اقل من ٥
و) ٥ او اكثر

٧ - عدد فروع الشركه (مكاتب المواقع)

أ) لا يوجد
ب) ١
جـ) ٢
د) ٣
هـ) ٤
و) ٥
ز) غيره (حدد) _____

٨) عدد فروع الشركة ، لايشمل مكاتب المواقع ،

أ) لا يوجد
ب) ١
جـ) ٢
د) ٣
هـ) ٤
و) ٥
ز) غيرها (حدد ــــــــــــــــــــ

٩) ما هي المشاريع التي حصل عليها عن طريق تقديم العطاءات (المناقصه التنافســـــيه)

أ) اقل من ٢٠ ٪
ب) ٢٠ ٪ اقل من ٤٠ ٪
جـ) ٤٠ ٪ اقل من ٦٠ ٪
د) ٦٠ ٪ اقل من ٨٠ ٪
هـ) ٨٠ ٪ – ١٠٠ ٪

١٠) ما هي نسبة المشاريع التي حصل عليها مقابل مبلغ ثابت (مبلغ مقطوع)

أ) – اقل من ٢٠ ٪
ب) ٢٠ ٪ اقل من ٤٠ ٪
جـ) ٤٠ ٪ اقل من ٦٠ ٪
د) ٦٠ ٪ اقل من ٨٠ ٪
هـ) ٨٠ ٪ ١٠٠٪

ثانيا) اسئلة خاصة بطرق التحكم بتكلفة
انشـــاء المشـــــــــروع

اختر الاجابة التى تناسب شركتك ، يمكنك اختيار اكثر من اجابة
(مقدار الفعاليه) فى الاسئلة التاليه تتعلق بمقدار فعالية الطريقة
المستخدمة لتحقيق الخصائص المذكوره فى القائمة المرفقة بحيث :-

١ = غير فعـــال .
٧ = فعـال جـدا

١ - ماهو متوسط نسبة العمل الذى يمنح لمقاول فرعى فى اى مشروع

أ) ٠ - اقل من ٢٠
ب) ٢٠ - اقل من ٤٠
ج) ٤٠ - اقل من ٦٠
د) ٦٠ - اقل من ٨٠
هـ) ٨٠ - اقل من ١٠٠

المميـــــزات : _____

المســـاوئ : _____

مقدار الفعاليه : ١ ٢ ٣ ٤ ٥ ٦ ٧

٢) الطريقة التى تستخدم فى هيكل تقسيم الاعمال للاستخدام فى المواقع تعتمد على :-

أ) تقسيم الاعمال الى مجموعات نموذجيه سابق تعرفها فى المكتب الرئيسى بحيث تستخدم فى جميع المشاريع (على اساس المواد الاساسيه او الكليه لكل مجموعة اعمال المهنه ، مثل اعمال النجاره) .

ب) تقسيم الاعمال الى مجموعات تم اعدادها خصيصا لهيكل تقسيم الاعمال .

ج) تقسيم الاعمال الى مجموعات اساسيه تبعا لمواقع العمل .

د) تقسيم الاعمال حسب الموارد الاساسيه لكل مدة زمنيه ، (اجهزة ، مواد بناء ، الخ .....)

المميزات : _____

المساوئ : _____

مقدار الفعاليه ـــ ١ ٢ ٣ ٤ ٥ ٦ ٧

٣) كم عدد الرموز التى تستخدم لربط هيكل تقسيم الاعمال بهيكل تقسيم الموظفين فى المشروع بالمعلومات الماليه :

أ) ١ - ١٥
ب) ١٦ - ٣٠
ج) ٣١ - ٤٥
د) ٤٦ - ٦٠
هـ) اكثر من ٦٠
و) لا يوجد

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٦ - ما الذى يستخدم للتخطيط والتحكم بالعمل فى الموقع :-

أ) مناقشة المشاكل المتعلقه بالمشروع خلال اجتماعات اسبوعيه فى الموقع .

ب) سجلات اسبوعيه تحدد الاعمال المزمع تنفيذها خلال الاسبوع التالى.

جـ) مخططات بيانيه تحدد وتوضح الانجاز الفعلى والانجاز المفترض (مخطط المستقيمات)

د) اجتماعات شهريه فى الموقع .

هـ) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٧) لمقارنة الاداء الفعلى بالاداء المرغوب فيه ، اى الطرق التاليه يستخدم لمقياس للاداء .

أ) مقارنة التكلفة الفعليه للاعمال المنجزه بالتكلفة المقدره فى التخمين لنفس هذه الاعمال .

ب) مقارنة التكلفة المقدرة فى التخمين بالتكلفة المتوقعه عند الانتهاء من المشروع .

جـ) مقارنة التكلفة الفعليه للوحدة من كمية العمل بالتكلفه التقديريه فى التخمين لنفس الوحده .

د) مقارنة التكلفة الفعليه بالتكلفة التقديريه فى التخمين لكل مجموعة اعمال المهنه .

هـ) تكلفة الوحده من كمية العمل المنجزه فى هذه الفترة بالتكلفه التراكميه الحاليه لوحدة العمل للفترة السابقة .

و) مقارنة التكلفة وكمية العمل والجدول الزمنى الفعلى بالتكلفه وكمية العمل والجدول الزمنى المرغوب فيه للاعمال المنجزه .

ز) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٨) المعلومات اللازمة لمقارنة الاداء الفعلى بالاداء المرغوب فيه تستقى من :-

أ) اسعار التخمين .
ب) سجلات المشاريع السابقة خلال مرحلة التنفيذ .
ج) فحص المواقع .
د) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٩) ما هى الفترة الزمنيه لقياس الاداء خلال التنفيذ وذلك لاصدار التقارير الخاصة بتكلفة التنفيذ .

أ) يوميا .
ب) اسبوعيا .
ج) شهريا .
د) كل (٣) اشهر .
هـ) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٠) لحساب تكلفة المشروع خلال الانشاء اى من الطرق التاليه يستخدم لحساب الساعات المستهلكه من قبل المقاول :-

أ) المراقبه الفرديه .
ب) سجلات خاصة لحساب ساعات الدوام (كتاب تسجيل الوقت)
د) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١١) لحساب تكلفة المشروع خلال الانشاء اى من الطرق التاليه يستخدم لحساب ساعات عمل الاجهزه :-

أ) كشف ملخص لفواتير استئجار الاجهزه .
ب) كشف يومى بساعات عمل الاجهزه لكل عنصر عمل .
ج) سجل بساعات عمل عمال الاجهزة (صفحة تسجيل الوقت) .
د) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٢) المواد المستهلكه خلال التنفيذ يتم حصرها .

أ) امر الشراء .
ب) الفواتير .
ج) سجلات خاصة بكميات المواد المستخدمة بكل عنصر عمل .
د) غيرها (حدد) _____

المميزات _____

المساوئ _____

١ ٢ ٣ ٤ ٥ ٦ ٧

١٣ - تكلفة موارد المشروع تحسب عن طريق :-

أ) حساب تكلفة العمال والأجهزة لكل ساعة خلال مرحلة التخمين وتبقى ثابته خلال مرحلة التنفيذ .

ب) حساب التكلفة الفعليه لكل ساعه .

ج) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٤) لتحويل الساعات المستهلكة للعمال خلال التنفيذ لبنود مالية أى من التالى يستخدم :

أ) ساعات العمل : الراتب الاساسى + المصاريف الاخرى (كبدل السكن)

ب) ساعات العمل : الراتب الاساسى فقط بينما تعامل المصاريف الاخرى كمصاريف عامة .

جـ) غيرها (حدد) _____

المميزات _____

المساوىء _____

مقدار الفعالية ١ ٢ ٣ ٤ ٥ ٦ ٧

١٥) لتحويل الساعات المستهلكة للعمال خلال التنفيذ لبنود مالية اى من التالى يستخدم :-

أ) ساعات الاجهزة : تكلفة الملكية + تكلفة التشغيل

ب) ساعات الاجهزة : تكلفة الملكية بينما تعامل تكلفة التشغيل كمصاريف عامة .

جـ - غيرها (حدد) _____

المميزات _____

المساوىء _____

مقدار الفعالية ١ ٢ ٣ ٤ ٥ ٦ ٧

١٦) فى حالة الانحراف عن الميزانيه او الجدول الزمنى للمشروع اى من التالى يستخدم للبحث والكشف عن السبب .

أ) التقص والبحث الغير رسمى .
ب) الاستنتاج والاستدلال العقلى .
ج) الحدس والبديهيه .
د) فحص نظامى للاعمال بغرض تطوير استخدام الموارد المتوفره اعتمادا على فحص عينات عشوائيه خلال مراحل العمل (دراسة العمل)
هـ) اجتماعات دوريه من قبل المسئولين عن المشروع (المشرفين)
و) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٧) فى حالة الانحراف عن الميزانيه ، اى من الطرق التاليه تستخدم لحساب مقدار الانحراف .

أ) ارقام مطلقه .
ب) النسبة من مقدار التخمين لكمية الاعمال .
ج) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٨) فى حالة الانحراف عن الميزانية اى من الطرق التاليه تستخدم لتصحيح الانحراف .

أ) استخدام الحوافز
ب) دراسة العمل
ج) حساب التكلفة التفصيليه للاعمال لكل عنصر عمل .
د) بطاقات عمل اسبوعية تحدد كمية الاعمال والوقت اللازم لانجازها من قبل فريق العمل .
هـ) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

١٩) استخدام الكمبيوتر فى مجال التحكم بتكلفة المشاريع يتم عن طريق :-

أ) استخدام جهاز مركزى فى المكتب الرئيسى .
ب) استخدام اجهزة الكمبيوتر فى الموقع .
جـ) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٢٠) للتحكم بكمية العمل المنجز والمواد المستخدمة اى من التالى يستخدم :-

أ) اشتراك المقاول والمقاول الفرعى فى قياس الانجاز
ب) تقارير عن وضع العمل صادرة من قبل المقاول الفرعى.
جـ) غيرها (حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

٢١) لحصر الخدمات والتكاليف خلال التنفيذ اى من التالى يستخدم :-

أ) تقارير صادرة من المقاول الفرعى .
ب) سجلات المشرف على العمل .
جـ) غيرها(حدد) _____

المميزات _____

المساوئ _____

مقدار الفعاليه ١ ٢ ٣ ٤ ٥ ٦ ٧

اسئلة تتعلق بالعوامل التى تؤثر
على درجة التحكم فى المشاريـــــع

من خلال خبرتك فى مجال الانشاء فى المنطقة الشرقيـه ، الرجاء تحديد مقدار تأثير العوامل التاليه على :-

أ) الفترة الزمنيه بين التقارير الخاصة بانشاء المشروع .

ب) درجة التقسيم فى هيكل الاعمال .

جـ) درجة التقسيم فى الهيكل التنظيمى للافراد العاملين فى المشروع .

استخدام مقياس رقمى متدرج من ١ – ٧ بحيث :-

١ = لا يوجد تأثير .
٧ = يوجد تأثير كبير .

أ) خصائص المشـــــروع :-

		الفترة الزمنيه	درجة التقسيم فى هيكل الاعمال	درجة التقسيم فى الهيكل التنظيمى .
١ –	حجم المشروع بالملايين	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢ –	نوع المشروع (مبانى هندسيه) الخ	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣ –	الجدول الزمنى الضيق للمشروع	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٤ –	درجة تعقيد المشروع	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٥ –	الجوده المرغوب فيها	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٦ –	موقع المشروع	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٧ –	غيرها (حدد)			
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١

ب) وثائق المشـــــروع :-

٨ -	بنود العقد (الشروط الجزائيه الخ)	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
٩ -	درجة اكتمال المخططات والمواصفات	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٠ -	وضوح اهداف المشروع	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١١ -	غيرها (حدد)			
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١

ج) العمـــــــال

١٢ -	انتاجية العمال المخفضه	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٣ -	عدد العمال المطلوب مقارنة بعدد العمال المتوفـــــر	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٤ -	مهارة العمال المطلوبه مقارنة بمهارة العمال المتوفـــره	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٥ -	المشاكل المتعلقة بعلاقات العمال	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٦ -	غيرها (حدد)			
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١

د) الاجهـــــزه

١٧ -	عدد الاجهزة المطلوبة مقارنة بالعدد المتوفر	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٨ -	نوع الاجهزة المطلوبه مقارنة بالمتوفر	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
١٩ -	غيرها (حدد)			
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١
	_____	٧١٥٤٣٢١	٧١٥٤٣٢١	٧١٥٤٣٢١

هـ) خصائص الشركه

٢٠)	حجم الشركه	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢١)	عدم الالفه او الجهل ببعض طرق الانشاء .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٢)	استخدام الكمبيوتر فى الموقع والمكتب الرئيسى .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٣)	وقت الحصول على المواد اللازمه والاجهزة والمواد .. الخ)	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٤)	ضعف النواحى الاداريه والفنيه	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٥)	درجة مصداقية التخمين (الدقه)	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٦)	عدد المشرفين المطلوبين مقارنة بالعدد الموجود .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٧)	عدد المشاريع المتوفره .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٨)	اسلوب ادارة المشاريع .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٢٩)	التغييرات المتواصله .	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٠)	غيرها (حدد)			
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١

و) مؤثرات خارجيـــــه

٣١)	التغييرات المتواصله فى القوانين الحكوميه	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٢)	التضخم	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٣)	الطقس	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٤)	المشاكل المفاجئه خلال التنفيذ	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٥)	المشاكل بين افراد المشروع بسبب العمل	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٦)	تدخل المالك خلال التنفيذ	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
٣٧)	غيرها (حدد)			
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١
	_____	٧٦٥٤٣٢١	٧٦٥٤٣٢١	٧٦٥٤٣٢١

اذا كانت لديك اية ملاحظات تساعد على اضافة معلومات تفيد البحث الرجاء اضافتها في الاسفل .

_____

_____

_____

_____

خصائص النظام الفعال للتحكم بتكلفة الانشاء

١ - توفير نظام جيد للتحكم بالتكلفة خلال مرحلة الانشاء وذلك بتعقب الزيادة فى التكلفة عن التكلفة المقرره فى الميزانيه واكتشاف الاسباب المؤديه الى هذه الزيادة ، المساعدة على اتخـــــاذ الاجراءات والطرق الكفيلة بمعالجة هذه الزيادة وقياس مـقـدار فعالية هذه الطرق .

٢ - البـــاطة ، حيث يمكن فهمـه من قبل جميع مختلف الطبقات العامله فى المشروع .

٣ - مرن الاستخدام ، حيث يمكن تطويعه حسب الحاجـه .

٤ - التحكم بالجدول الزمنى للمشروع .

٥ - التحكم فى الانجـــاز .

٦ - توفير عائد للمعلومات لوضع المشروع خلال مراحل الانشاء .

٧ - توفير المعلومات اللازمه لقياس مقدار الاختلاف بين العمل المنجـز والعمل المفتـرض انجازه .

APPENDIX B
INFORMATION ABOUT CONTRACTORS' FIRMS

JOB SIZE:

Table 32 summarizes the maximum job size handled by the respondents. This average job size was classified according the standard classification of the Agency of Classification of Contractors in Riyadh (Chapter 4, Page 49).

Table 32 : Maximum Job Size.

Maximum Job Size (Millions of SR.)	Grade	No. of Respondents	%
1.Under of equal to 5	5	19	42.2%
2.Over 5 - 15	4	12	26.7%
3.Over 15 - 50	3	5	11.1%
4.Over 50 - 200	2	3	6.7%
5.Over 200	1	6	13.3%
Total		45	

From this table, approximately 69% of the respondents are from the fifth and fourth grade contractors. This finding seems consistent with the actual market condition, since most of the contractors work on a small scale, since forming a big company requires lots of financial support.

TYPE OF CONTRACTORS:

Table 33 summarizes the activities the respondents are involved in beside building construction. From this table, the following could be concluded:

* Most of the contractors are concentrated within the main three types of work; building, engineering and industrial, while a very small percentage is involved in other activities beside building construction, for example specializing in steel construction or interior design.
* Most of the respondents are involved in building construction alone. One of the main reasons for specialization in only one type of work is the skill and resources required for each type, which makes it more efficient to concentrate on one type only.
* With reference to the lists of contractors prepared by the Eastern Province Chamber of Commerce, it was noticed the majority of the contractors are involved in building construction, and this justifies the generalization that building construction is the bulk of construction industry in the Eastern Province of Saudi Arabia.

Table 33 : Type of Contractors.

Contractor Type		Contractor Grade 5	4	3	2	1	Total
Building	No.	15	5	3	0	2	25
	%	79%	41.7%	60%	0.0%	33.3%	55.6%
Building & Engineering	No.	1	1	1	1	3	7
	%	5.3%	8.3%	20%	33.3%	50%	55.6%
Building & Industrial	No.	2	4	1	1	0	8
	%	10.5%	33.3%	20%	33.3%	0.0%	17.8%
Building Others	No.	1	1	0	0	0	0
	%	5.3%	8.3%	0.0%	0.0%	0.0%	4.4%
Building & Eng. & Ind.	No.	0	1	0	1	1	3
	%	0.0%	8.3%	0.0%	33.3%	16.7%	6.7%
Total		19	12	5	3	6	45

NUMBER OF PERMANENT EMPLOYEES:

Building construction is characterized as a *labor intensive* profession. Table 34 presents the number of permanent employees in the firms of the selected sample. From this table, it can be noticed most of the contractors have less than three hundred permanent employees. It can also be seen that most of the contractors involved in this study have their permanent employees approximately proportional to the respective grade. However, the second grade contractors do not have a number of employees adequate for

the size of the projects they handle. This is mainly due to their involvement in other types of work like engineering and industrial construction, which depend on equipment rather than labor (Table 33).

Table 34 : No of Permanent Employees.

Number		Contractor Grade 5	4	3	2	1	Total
a. Under 100	No.	14	3	0	0	0	17
	%	73.7%	25%	0.0%	0.0%	0.0	37.8%
b. 100-299	No.	4	3	2	2	1	12
	%	21.1%	25%	40%	66.7%	16.7%	26.7%
c. 300-499	No.	0	2	1	0	0	3
	%	0.0%	16.7%	20%	0.0%	0.0%	6.7%
d. 500-699	No.	0	3	1	0	0	4
	%	0.0%	25%	20%	0.0%	0.0%	8.9%
e. Over 699	No.	1	1	1	1	5	9
	%	5.3%	8.3%	20%	33.3%	83.3%	20%
Total		19	12	5	3	6	45

CONSTRUCTION EQUIPMENT:

Tables 35 and 36 summarize the value of construction equipment owned and the percentage of equipment leased or rented. Table 35 shows the majority of the contractors have their construction equipment less than or equals ten million SR. This table shows the low value of equipment owned, except for the first and second grades. This result is consistent with the findings of the previous section, where the

involvement with engineering and industrial projects shifted the attention towards concentrating on equipment rather than labor, specially for grade # 2 contractors. On the other hand, grade # 1 contractors have a high value of equipment, due to their involvement with large scale projects that makes it more profitable to own the equipment rather than to rent it.

Table 36 illustrates a very low percentage (less than 25%) of leased or rented by the majority of the contractors. However, by analyzing this percentage for each grade, it can also be observed that a low percentage of equipment is leased or rented, except for grade # 5 and partially for grade # 4 contractors. This finding is consistent with the previous observation, that big and medium size contractors can afford to buy most of the equipment needed. On the other hand, small size contractors can not afford to buy all that they need. During the course of interviews, most of the respondents also justified this by unstable market conditions, where some contractors stay for several months without any work to do. This unstable market condition has arisen from the huge number of small contractors with few projects available.

Table 35 : Value of Construction Equipment Owned. (millions of SR).

Equipment Value		Contractor Grade 5	4	3	2	1	Total
Under 1	NO. %	13 68.4%	6 50%	0 0.0%	0 0.0%	0 0.0%	19 42.2%
1- Under 10	No. %	4 21.1%	4 33.3%	2 40%	0 0.0%	0 0.0%	10 22.2%
10 - Under 20	No. %	1 5.3%	0 0.0%	1 20%	0 0.0%	1 16.7%	3 6.7%
20 - Under 30	No. %	0 0.0%	1 8.3%	0 0.0%	1 33.3%	1 16.7%	3 6.7%
30 - Under 40	No. %	0 0.0%	1 8.3%	0 0.0%	2 66.7%	0 0.0%	3 6.7%
40 - Over	No. %	1 5.3%	0 0.0%	2 40%	0 0.0%	4 66.7%	7 15.6%
Total		19	12	5	3	6	45

Table 36 : Percentage of Equipment Leased or Rented

Percentage		Contractor Grade 5	4	3	2	1	Total
None	No.	1	3	1	2	0	7
	%	5.3%	25%	20%	66.7%	0.0%	15.6%
< 25%	No.	10	5	4	0	4	23
	%	52.6%	41.7%	80%	0.0%	66.7%	51.1%
25%-Under 50%	No.	5	1	0	1	1	8
	%	26.3%	8.3%	0.0%	33.3%	16.7%	17.8%
50%- Under 75%	No.	2	2	0	0	1	5
	%	10.5%	16.7%	0.0%	0.0%	16.7%	11.1%
75% - 100%	No.	1	1	0	0	0	2
	%	5.3%	8.3%	0.0%	0.0%	0.0%	4.4%
Total		19	12	5	3	6	45

AVERAGE JOB DURATION:

Table 37 shows the majority of the contractors have projects with an average duration between one and two years. According to this table, the average job duration for the first and second grade contractors is approximately between 2 and 5 years, while the rest of the grades is less than two years. This is consistent with the fact that, as the project size increases, it requires more time to complete. In addition, the higher grade number contractors are heavily dependent on residential and commercial buildings, specially villas, which require an average time of one year to complete.

Table 37 : Average Job Duration (years).

Job Duration		Contractor Grade 5	4	3	2	1	Total
Under 1/2	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
1/2 Under 1	No.	3	1	0	0	0	4
	%	15.8%	8.3%	0.0%	0.0%	0.0%	8.9%
1 - Under 2	No.	14	11	4	0	1	30
	%	73.7%	91.7%	80%	0.0%	16.7%	66.7%
2 - Under 3	No.	0	0	1	2	3	6
	%	0.0%	0.0%	20%	66.7%	50%	13.3%
3 - Under 5	No.	0	0	0	1	1	2
	%	0.0%	0.0%	0.0%	33.3%	16.7%	4.4%
5 or more	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
Total		19	12	5	3	6	45

NUMBER OF OFFICES:

Tables 38 and 39 show the number of branch offices and site offices of the respondents' firms. Table 40 shows more than one third of of the contractors do not have any branch offices. On the other hand, the rest have either one or two branch offices.

More than half of the fifth grade contractors do not have any branches. On the other hand, more than half of the first grade contractors have two or more branches, rising to a maximum of six branches in the Kingdom.

During the course of interviews, it was found that most of the first and second grade contractors are foreign companies. Most of these companies have their head offices in their home countries and have their branches in different parts of the Kingdom.

Table 39 shows that less than one quarter of the contractors have no site offices, while the rest are not concentrated around any specific number.

More than one third of the fifth grade contractors have no site offices, while half of the first grade contractors have five site offices, or more, in the Eastern Province. The main reason for this is that the first grade contractors treat the site offices as branch offices where they are equipped with all basic needs to control the project in terms of staff and equipment. On the other hand, for the fifth grade contractors, the site office is just a simple shelter for the responsible engineer for daily follow-up. The second, third and fourth grade contractors are between these two extremes.

Table 38 : No. of Branch Offices.

No. of offices		Contractor Grade 5	4	3	2	1	Total
None	No.	10	4	1	0	1	16
	%	52.6%	33.3%	20%	0.0%	16.7%	35.6%
1	No.	3	3	0	0	0	6
	%	15.8%	25%	0.0%	0.0%	0.0%	13.3%
2	No.	3	3	2	1	3	12
	%	15.8%	25%	40%	33.3%	50%	26.7%
3	No.	3	1	1	1	0	6
	%	15.8%	8.3%	20%	33.3%	0.0%	13.3%
4	No.	0	0	1	1	0	2
	%	0.0%	0.0%	20%	33.3%	0.0%	4.4%
5	No.	0	0	0	0	1	1
	%	0.0%	0.0%	0.0%	0.0%	16.7%	2.2%
6	No.	0	1	0	0	1	2
	%	0.0%	8.3%	0.0%	0.0%	16.7%	4.4%
Total		19	12	5	3	6	45

Table 39 : No. of Site Offices.

No. of offices		Contractor Grade 5	4	3	2	1	Total
None	No.	7	1	0	1	1	10
	%	36.8%	8.3%	0.0%	33.3%	16.7%	22.2%
1	No.	4	1	0	0	0	5
	%	21.1%	8.3%	0.0%	0.0%	0.0%	11.1%
2	No.	4	1	0	1	1	7
	%	21.1%	8.3%	0.0%	33.3%	16.7%	15.6%
3	No.	1	2	2	1	0	6
	%	5.3%	16.7%	40%	33.3%	0.0%	13.3%
4	No.	1	5	0	0	0	6
	%	5.3%	41.7%	0.0%	0.0%	0.0%	13.3%
5	No.	0	1	0	0	3	4
	%	0.0%	8.3%	0.0%	0.0%	50%	8.9%
6	No.	0	0	3	0	1	4
	%	0.0%	0.0%	60%	0.0%	16.7%	8.9%
8	No.	2	1	0	0	0	3
	%	10.5%	8.3%	0.0%	0.0%	0.0%	6.7%
Total		19	12	5	3	6	45

PROJECTS AWARDING:

Table 40 shows the percentage of work awarded through competitive bidding. According to this table, it can be seen that there is a general trend towards awarding projects through bidding, in the private as well as in the public sector. This general trend gives an indication that people have started to become very selective in having their

projects built. However, the following was found during the interviews:-

1. Most of the projects awarded through competitive bidding are public projects.
2. The private projects awarded through competitive bidding are mainly large scale projects and awarded to the first, second and third grade contractors.
3. The private projects obtained by the fifth and fourth grade contractors are mainly on negotiation basis. However, even with this form of contract, the owner gets different prices from different contractors to achieve the scope of work and in turn to select the cheapest.

Table 40 : Percentage of Work Awarded through Competitive Bidding.

Percentage		Contractor Grade 5	4	3	2	1	Total
Under 20%	No.	5	1	0	0	3	9
	%	26.3%	8.3%	0.0%	0.0%	50%	20%
20% - Under 40%	No.	4	1	0	1	1	7
	%	21.1%	8.3%	0.0%	33.3%	16.7%	15.6%
40% - Under 60%	No.	2	0	0	0	0	2
	%	10.5%	0.0%	0.0%	0.0%	0.0%	4.4%
60% - Under 80%	No.	3	3	0	1	2	9
	%	15.8%	25%	0.0%	33.3%	33.3%	20%
80% - 100%	No.	5	7	5	1	0	18
	%	26.3%	58.3%	100%	33.3%	0.0%	40%
Total		19	12	5	3	6	45

Table 41 shows that the majority of the projects are awarded as lump sum contracts. This trend is explained as follows:-

* Most of the projects of the first and second grade contractors are public and it is well known that public contracts are awarded as lump sum with defined scope of work.
* A high percentage of the work of the third, fourth and fifth grade contractor is for the private sector. However, almost all owners request a fixed price to achieve the scope of work of their projects. This gives the owners a more conservative way to build their projects and lessens the risk from their side.

Table 41 : Percentage of Lump Sum Contracts.

Percentage		Contractor Grade 5	4	3	2	1	Total	
Under 20%	No.	5	0	0	0	1	6	
	%	26.3%	0.0%	0.0%	0.0%	16.7%	13.3%	
20% - Under 40%	No.	4	0	0	0	0	4	
	%	21.1%	0.0%	0.0%	0.0%	0.0%	8.9%	
40% - Under 60%	No.	1	1	1	1	1	5	
	%	5.3%	8.3%	20%	33.3%	16.7%	11.1%	
60% - Under 80%	No.	0	5	1	1	1	8	
	%	0.0%	41.7%	20%	33.3%	16.7%	17.8%	
80% - 100%	No.	9	6	3	1	3	22	
	%	47.4%	50%	60%	33.3%	50%	48.9%	
Total		19	12	5	3	6	45	

APPENDIX C
DISCRIMINANT ANALYSIS

DISCRIMINANT ANALYSIS

The basic assumptions upon which Discriminant Analysis is based are as follows:

1. Two or more groups.
2. At least two cases per group.
3. Any number of discriminating variables that is less than the total number of cases minus two.
4. Discriminant Analysis is measured at the internal level.
5. No discriminating variables may be a linear combination of other discriminating variables.
6. The covariance matrices for each group must be (approximately) equal unless special formulas are used.
7. Each group has been drawn from a population with multivariate normal distribution on the discriminating variables.(41)

In order to conduct Discriminant Analysis, at least the first five assumptions have to be satisfied as was the case in this research.

When running the Discriminant Analysis, different functions are produced. Abbreviated by (CAN), each function assigns a discriminating value to each of the studied factors. The factor with the highest value is the most powerful discriminator. The number of functions produced is equal to the number of discriminating variables minus one, or the number of groups minus one, whichever is smaller. In this research the number of functions = 4 (5 grades - 1 = 4). The discriminating functions are normally produced in a descending order, where (CAN1) is the most powerful discriminating function, and so on. These functions depend on the concept of Residual Communications. This concept utilizes the ability of the variables to discriminate among the groups beyond the information that has been extracted from the previously computed functions (41).

Normally not all the functions produced are important discriminators. For this reason canonical coefficients are used. The value of a canonical coefficient is normally ≥ -1 and ≤ 1. So the closer the value of the coefficient is to 1 or -1, the more powerful the discrimination is. Normally CAN1 and CAN2 are the most important functions to describe the discrimination.

Square canonical correlation is also used to test if the proportion of variation in the discriminant function is explained by the groups. These groups are classified according to the discriminating variables, which are the contractors grades in this research. The higher the value of square canonical correlation, the more discrimination exists among the groups (41). The EIGEN VALUE is also used for the same purpose and in the same way.

To check if the sampling process produced a case which shows the compute degree of discrimination, when in fact there are no group differences in the population, WILK'S LAMBDA is used. If the value of Lambda gets close to zero, the groups' centroids are greatly separated and very distinct relative to the amount of disparity within the groups (41).

To study the factors that have the most powerful effect on discrimination, the functions (CAN) should first be selected on the basis of the corresponding canonical correlation. Two approaches can be used to determine the discriminating factors:

1) TOTAL CANONICAL STRUCTURE: In this method, the factors which have a correlation value $\geq .3$ regardless of the sign are considered as powerful discriminators (42).

2) STANDARDIZED CANONICAL STRUCTURE: This method depends on standardizing the correlation coefficients on the Normal Distribution Curve. Since most of the functions are contained within two standard deviations ($\pm 2\sigma$) around the grand centroid ($\sigma = 0$) the factors which are outside this range are considered powerful discriminators (42).

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